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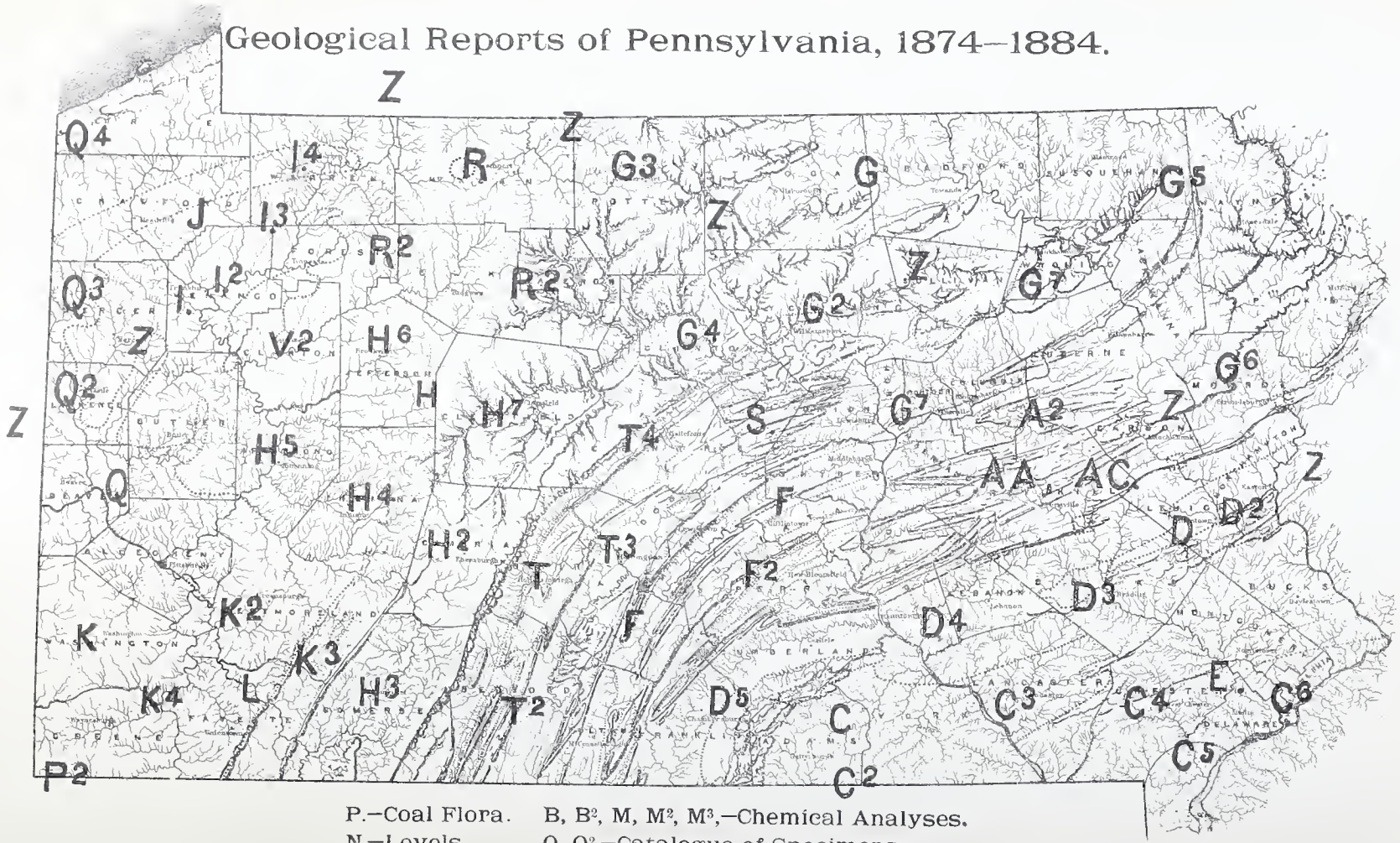

P.—Coal Flora. B, B², M, M², M³,—Chemical Analyses.
N.—Levels. O, O²,—Catalogue of Specimens.

SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA.

REPORT OF PROGRESS

RR, PART II.

THE TOWNSHIP GEOLOGY

OF

ELK AND FOREST COUNTIES,

BY

CHARLES A. ASHBURNER,

AND OF

CAMERON COUNTY

BY

ARTHUR W. SHEAFER.

RELATES ESPECIALLY TO THE GEOLOGY OF THE COAL MEASURES OF THE CARBONIFEROUS AGE.

TO WHICH ARE APPENDED

1. DRILLINGS FOR COAL IN SERGEANT TOWNSHIP, McKEAN COUNTY. A CORRESPONDENCE BY N. F. JONES, J. P. LESLEY, AND C. A. ASHBURNER.
2. NOTES ON IRON ORE IN CAMERON COUNTY, BY C. A. ASHBURNER.

ILLUSTRATED BY 30 PAGE PLATES AND 1 MAP; ACCOMPANIED BY AN ATLAS (RR) CONTAINING 11 SHEETS OF MAPS AND SECTIONS.

HARRISBURG:
PUBLISHED BY THE BOARD OF COMMISSIONERS
FOR THE SECOND GEOLOGICAL SURVEY.
1885.

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LETTER OF TRANSMITTAL.

To His Excellency Governor ROBERT E. PATTISON, *ex-officio Chairman of the Board of Commissioners of the Second Geological Survey of Pennsylvania:*

SIR: I have the honor to submit that part of the Report of the Progress of the Survey in Cameron, Elk and Forest counties, which gives the details of the examinations made in each township.

The preparation of this report and its illustrations was begun at the close of the field work of 1879; but was necessarily suspended when, in the early summer of 1880, Mr. Ashburner was detailed to organize that survey of the Anthracite coal fields which he has been so ably conducting ever since.

No care was spared by Mr. Ashburner and his skillful assistant Mr. Sheafer in their efforts to see clearly and state accurately the facts made public by this report; and the success with which they have worked out the geology of the district embracing these three counties may be ascribed to the assiduous zeal with which they had previously carried on instrumental surveys in the adjoining district of McKean county, the Report of which (R) was published in 1880, with an Atlas of maps and sections.

I feel confident that the statements made in this report will not only be found correct, but that they will afford a sure base of operation for private investigators.

I am, sir, very respectfully,

Your obedient servant,

J. P. LESLEY.

March 14, 1885.

907 Walnut Street.
Philadelphia, *March 1, 1885.*

Prof. J. P. Lesley, *State Geologist,*
1008 Clinton Street, Philadelphia:

Dear Sir: I have the honor to submit herewith Part II of the report of the progress of the Survey in Elk, Forest, and Cameron counties, giving a detailed description of the geology relating to the coal beds and the strata outcropping above water level in the townships of these three counties.

The manuscript for Part I of this report is largely prepared for the press, and will contain a summary description of the connected geology of the three counties, records and descriptions of the oil wells, and a general discussion of the geology of the district as related especially to the oil rocks.

A division of my report was desirable, from the fact that some persons are interested chiefly in facts relating to the coal, and others are chiefly concerned with the exploration and exploitation of the district for petroleum.

An atlas of 11 sheets, relating both to the coal and petroleum geology, was published in advance of the report, in November, 1884. For a description of those sheets in the atlas which relate particularly to the structure of the rocks below water level, as exhibited in the records of the boreholes and the geology of petroleum, the reader is referred to Part I.

My examinations in these counties were commenced in July, 1876, in conjunction with the survey of McKean county. During the field season of that year, a general reconnaissance of the four counties was made, in order to better appreciate the special difficulties connected with a geological examination of this part of the State, and to better plan a more detailed survey. The survey of McKean county was completed in the autumn of 1878. More than half of the field season of that year, however, was spent in parts of

the other three counties, especially Elk. In the spring of 1878, Mr. A. W. Sheafer was commissioned as my aid, and assisted me during that and the following year in the survey, particularly in Cameron and Forest counties.

A great deal of Mr. Sheafer's work in Cameron county, although under my personal direction, was carried on independently by him in the field. His early command of the problems to be solved in the geology, and his clear appreciation of the difficulties which had led other geologists astray and which must be overcome before these problems could be solved, rendered him a valuable aid, not only in studying the geology of the district to which his field work was confined, but also in helping me to arrive at conclusions as to the geology of other districts, examined in the field exclusively by myself. The writing of the township report of Cameron county I assigned to him.

The economical questions which were involved in the survey of this district are of the greatest importance, on account of the diverse views held and the reports which had been published in regard to the existence and mining of coal and iron. The satisfactory solution of these questions depended, not only upon the conclusions to be derived from the study of the local rock outcrops, but from a determination of the relationship which exists between the strata in these three counties and in those surrounding them, especially to the south-west. The results of the survey, in Elk county particularly, differed so widely from the views which had previously been held by geologists that it was deemed advisable to delay their publication until the completion of the surveys in the surrounding counties, and an extension of some of my lines of investigation into these areas.

In the summer of 1880, after the completion of the illustrations contained in the atlas accompanying this report, I was directed to commence the survey of the anthracite coal fields. Upon accepting this commission, my work in the north-western counties was necessarily suspended and was not resumed again until the fall of 1883, when, the surveys in the surrounding counties having been completed, I spent two months in the field in order to collate the results of

the work in my district with those of the assistants in adjoining counties.

The coal beds of the district which can be profitably mined seem to be confined to the counties of Elk and Cameron; the former county containing more coal beds, better coal beds, and beds underlying greater areas than the latter. These coal areas have been reported on with such minuteness in the body of the report that it is not necessary to refer to them further in this place. It may be said, however, that a number of areas in these two counties which have formerly been supposed to be valuable as coal properties, I consider of very little value, as such; while other areas, notably some of those in the Toby Creek and Shawmut coal basins, which have been considered by many geologists and coal men to be of questionable value as mining properties, I am disposed to attach greater value to.

Although numerous coal outcrops have been opened in Forest county, I believe no coal beds exist there which, with the present facilities for mining and the present demands of the market, are of workable thickness or contain marketable coal.

Petroleum and natural gas have been found in large quantities in the western part of the district, confined almost exclusively to areas within the boundaries of Forest county, although several small oil wells and a number of gas wells of considerable size have been found in the western part of Elk county, within two or three miles of the Forest county line, and north of Wilcox. A gas well of considerable size has also been obtained near Ridgway. Special account of the petroleum and gas will be made in Part I.

I desire to state in this connection that the facts bearing upon the geological structure of Elk and Cameron counties, which have been obtained from the surface explorations and from the records of the numerous drill holes which have been bored, lead me to conclude that the geological conditions characteristic of the productive oil areas in Pennsylvania do not exist in Cameron county, or in that portion of Elk county east of a line drawn through Spring Creek and Wilcox; and therefore that boring for oil east

of this line will be prosecuted under great risks, with all the chances against finding oil in paying quantities. Facts are given relating to Elk county north-west of the line through Spring Creek and Wilcox which leave little hope of the existence of oil in paying quantities except west and north of a broken line passing through Spring Creek, Spring Creek Summit, Highland, and Wilcox ;* the details of which will appear in Part I.

This conclusion seems to be warranted by a comparison of the facts obtained in the district referred to with those observed in the proven oil territories.

Geologists who attempt to predict places where oil will be found outside of the boundary line of developed territory, and the amount of oil to be looked for, attempt to arrive at conclusions for which there are not sufficient facts. Geologists can, however, by a study of the geological conditions which are always found to accompany the existence of oil and by defining the undeveloped territory where such conditions are found to exist, draw, in many instances, sharp lines between areas where it would be folly to drill for oil, and other areas where there is a possibility of finding oil. The actual existence of oil cannot be determined except by drilling ; but this does not preclude the geologist from aiding the oil man even in developed territory, for, I believe that if the geological conditions attending the existence of oil in certain wells in a producing territory be carefully studied much money may be saved oil drillers by a better location of the wells which he can reasonably hope to be producers, rather than by drilling on the basis of favored theories or upon conclusions illogically deduced.

Valuable beds of fire-clay have been worked in several localities in the district, and reference has been made to them in the body of the report.

Great expectations have been entertained by many residents and local geologists in Cameron, Elk, and Forest counties that valuable iron ore beds might be discovered. As to what hope may be warranted for realizing this expec-

*See the map of Elk county, Plate II in the Atlas.

tation the numerous facts bearing upon the subject, scattered through the body of the report and in Appendix B, amply attest. I need only state here that no development has ever been made in any of the three counties, which would lead a practical geologist or iron miner to suspect that any bed will be discovered from which ore might be profitably mined either for shipment to distant furnaces or for consumption at local works.

In addition to the minerals above noted, there have been found in the district other minerals in quantities so small as to be of no practical value whatever. Among the latter may be instanced gold and silver. The occurrence of these is so rare and the quantities in which they have been found are so extremely small that they have only served to excite wild speculations and to furnish material for sensational publications. Traces of these two metals have been discovered associated with plates of coal and plant remains in the Pocono Sandstone No. X in Trout run, in the northern part of Jay township below Jacob Hanes' house. Considerable exploration has been made at this point with the hope of finding rich deposits of these two metals, and numerous assays have been made of selected pieces of rock containing them. No indications exist, however, which would lead us to suspect that anything more than mere traces of these metals, in quantities too small to pay for working, will ever be found in Elk or the adjoining counties.

A summary statement of the geology of the entire district will be given in Part I. The method pursued in local descriptions and cross references, together with the voluminous index, render a general descriptive chapter for Part II unnecessary.

In conclusion, it would seem almost unnecessary to state that persons residing in the district, or having interests in it, gave me all possible assistance in furthering the plans of the Survey. These persons are too numerous to be named here; many of them are referred to in the body of the report in connection with the special assistance rendered in each case. Among those, however, who aided me more particularly and whose valuable services demand more than a

general acknowledgment, I desire to mention the following gentlemen: Hon. Lewis Emery, Jr., of Bradford; Hon. J. L. Brown, of Wilcox; Capt. A. A. Clay, of Upland; Mr. Graham Macfarlane, of Towanda; Mr. A. B. Howland, of Titusville; Messrs. E. E. Willard, D. C. Oyster, George A. Rathbun, and Dr. C. R. Earley, of Ridgway; Messrs. D. Robertson and W. A. Wentworth, of Dagus Mines; Mr. W. A. May, of Scranton; Mr. D. Eldridge, of Erie; Mr. William A. Baldwin, of Pittsburgh; Mr. A. B. Starr, of Allegheny; Mr. John Brooks, of Sinnemahoning; Mr. John H. Mayo, of Brookline, Mass.; Messrs. Kaul and Hall, Coryell and Rush and Joseph Patton, of St. Mary's; Messrs. Joseph Lesley, William Hacker, Robert P. Field, and Henry Clay, of Philadelphia; and finally the late General Thomas L. Kane, of Kane; Mr. M. M. Schultz, of Wilcox; and Mr. Howard Fry, of Williamsport.

Mr. Arthur W. Sheafer aided me in the field work and in the preparation of several of the sheets contained in the atlas during the years 1878 and 1879, and has written the report on the township geology of Cameron county.

Mr. O. B. Harden executed the drawings, which have been photo-electrotyped and published as page plates.

These drawings were constructed on double the scale on which it was intended they should be printed. By an error of the photo-electrotyper all the drawings, except those on pages 226, 230 and 234, which are correctly reduced from 1 to .5 have been reduced from 1 to .464. No inconvenience should result from this error of publication, since measurements are given of certain intervals on each page.

Mr. Frank A. Hill, aided by Mr. Clarence R. Claghorn, prepared the index.

Mr. Charles B. Scott aided me generally in the preparation of the manuscript of the report and in proof-reading.

In submitting this report, I desire to acknowledge the invaluable advice and assistance you have afforded me at all times during the progress of this survey.

I remain, with great respect,

Your obedient servant,

CHARLES A. ASHBURNER.

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REPORT OF THE PROGRESS

OF THE

SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA

IN

CAMERON COUNTY,

By A. W. Sheafer.*

DETAILED GEOLOGY OF THE SEVERAL TOWNSHIPS.

Chapter I.

Shippen township.

This township, the largest in the county, occupies its western and northwestern part, having McKean on the north and Elk on the south and west.

With the exception of the small area in the St. Mary's coal basin tributary to the Allegheny drainage basin, the township is drained by the Sinnemahoning creek.

North of the Philadelphia and Erie RR. the drainage is into the Driftwood branch, the Portage and West creeks together with their larger tributaries; south of the railroad into Canoe, Sterling, and Hick's runs, the latter emptying into the Bennett's branch.

Northwest of the Boon's Mountain anticlinal the town-

*The field work of the Cameron county survey was done jointly by myself and aid Mr. A. W. Sheafer. The bulk of the sectional measurements were made by Mr. Sheafer. C. A. A.

ship is an elevated table land over 2,000 feet in height, with broad flat summits and steep but drift-covered hill slopes. South of this anticlinal the surface slopes gradually towards the synclinal axis of the Cameron coal basin where the elevation rarely exceeds 1,700 feet.

This anticlinal itself, from Emporium to the southwest, forms a very prominent elevated ridge containing summits rising to 2,100 feet above tide.

The highest point measured in the county is the river hill immediately south of Emporium Junction, whose top was found to be *2085* feet above tide. South of this summit there is one which appears to be higher, but its elevation was not determined.

The lowest point is where the Sinnemahoning crosses the eastern township line; its elevation is about 1000 feet.

The Boon's Mountain (third) anticlinal axis enters the township near the southwest corner and follows the valley of West Creek to Emporium where it makes a break along the Kinzua-Emporium axis; starting again in its north east course 5 miles to the west, it leaves the township near the northeast corner. The synclinal axis of the Cameron coal basin crosses the double southeast corners of the township and enters Lumber township near the mouth of Canoe run.

The Kinzua-Emporium cross anticlinal follows the general course of the Driftwood branch from Emporium as far west as the mouth of North creek, to which point it is well defined by the northeast dips in the Chemung rocks. To the west of this point, however, its direction is obscure on account of the absence of exposures. Its crest line through this portion of the township, as drawn on the geological map, is made to connect with the point on West creek, Elk county, where this axis again shows itself.

The eastern edge of the St. Mary's (fourth) bituminous basin, with its outlying patches of coal, crosses the northwestern corner of the township.

The rocks exposed in this township extend from the Chemung up into the Productive coal measures, and have a total thickness of 1635′ distributed as follows:

Lower Productive Coal Measures,	135′
Pottsville Conglomerate, No. XII,	200′±
Mauch Chunk Red Shale, No. XI,	50′
Pocono Sandstone, No. X,	550′
Catskill, No. IX,	350′
Chemung, No. VIII,	350′+
Total,	1635′±

There is no one locality in the township where this thickness exists above water level; but it does occur as shown by the geological map, between West Creek station and the Cameron coal mine.

The above thickness of the several formations are typical only for the eastern portion of the township, since, as has been stated, the measures all thin to the northwest.

The coal measures of the township are confined to the southeastern and northwestern portions, and are contained in the Cameron (Third Bituminous) and the St. Mary's (Fourth Bituminous) coal basins. The greater portion of the coal area, as shown by the map, is in the Cameron basin, for a detailed description of which the reader is referred to the chapter on the *Cameron coal basin.* As stated in the general description of the Lower Productive coal measures and the Conglomerate series, the workable coals are not confined to the coal measures proper, but occur as far down in the *Conglomerate* as the KINZUA CREEK SANDSTONE, constituting the important *Alton coal group.* For this reason the coal areas on the geological map include all of the coal measures proper and all that portion of the conglomerate series above the KINZUA CREEK SANDSTONE.

The St. Mary's Coal basin in Cameron county, situated as it is so far away from any railroad, has never been systematically developed, and as a consequence it was impossible to obtain a section of the coals or to collect any definite information as regards their thickness or character.

The main portion of the coal area in this basin lies west of the northern branch of the third anticlinal axis, and north of the Kinzua-Emporium cross axis. This axis combined with the great breadth and height of the southern branch of the third axis—the Boon's Mountain anticlinal—has elevated the measures between the Driftwood branch and West creek

to such a height that only a few of the highest summits catch the coal-bearing strata. On one of these summits in warrant 2486 Mr. Nathan Howsler is reported to have opened a coal bed which is possibly one of the Alton group. On the lands of the McKean, Elk Land and Improvement Company warrant 2442 (?) Mr. Burlingame reported a coal bed with over 100 feet of cover above it. Although, as stated, the coal area has been so little proven in this portion of Cameron county, yet on account of thorough developments in this same basin in the vicinity of Norwich, McKean county, but a short distance north of the county line, and on account of the persistency of these coals, we are enabled to form a correct idea of the coal section. The sections of the measures in this basin, where developed at St. Mary's, Elk county, and Norwich, McKean county, are so similar, though miles apart, that there can be no doubt as to a like section existing in Shippen township.

The following section of the Norwich coal basin in McKean county is reproduced from Report R, page 99, and no doubt is true for Cameron county:

Lower portion Lower Productive coal measures, No. XIII.

1.	Shales,	15′±
2.	Gray slate,	3′
3.	*Dagus coal*,	5′
4.	Fire clay,	1′ 6″±
5.	Shale and sandstone,	40′
6.	*Coal*,	3′ 6″
7.	Fire clay,	1′ 6″
8.	Shale and slate,	3′ 3″
9.	*Clermont coal*,	1′ 6″
10.	Fire clay,	1′ 6″±

Pottsville Conglomerate, No. XII.

11.	Johnson Run Sandstone,	50′
12.	Black slate,	5′
13.	*Alton Upper coal*,	2′ 6″
14.	Fire clay and shale,	8′
15.	*Alton Middle coal*,	9″
16.	Shale and sandstone,	4′ 3″
17.	*Alton Lower coal*,	4′
18.	Fire clay,	2′±

19. Kinzua Creek Sandstone,	48′
20. *Marshburg Upper coal*,	2′ 4″
21. Fire clay,	2′ 8″
22. Olean Conglomerate and Sandstone,	55′
Total,	260′ 6″

The area of the *Dagus coal* (stratum No. 3,) is very limited in the Norwich basin only being contained in the highest knolls, and then with but little cover. In Cameron county, however, its area should be somewhat greater since the coals as you approach the south lie at a lower level.

Further to the south in the vicinity of St. Mary's, where it is the principal coal mined, its thickness varies between 3 and 4 feet.

The coal (stratum No. 6,) 41′ 6″ below the *Dagus coal* seems to be a local coal, or at least confined to this portion of the basin, since nowhere else in the northern counties is it found in such development.

Mr. Ashburner considers it to occupy the horizon of the *Clermont or Ferriferous* limestone which has not been found in this basin northeast of St. Mary's.

The *Clermont* coal where opened in the Norwich basin has shown a thickness of but 1′ 6″, but as these measurements were made at the outcrop, the figures are undoubtedly too small.

At the headwaters of Indian run on the Cameron and McKean line this coal is reported to be 4′ thick. The same bed has been mined at St. Mary's, Elk county, and Clermont, McKean.

The *Alton coals* (strata Nos. 13–15 and 17) are the principal coals of McKean county. They cover a greater area and consequently have been more extensively worked than the Clermont and Dagus beds.

The analyses of the coals of this section as published in Report R, Chapter IX, are given the following table:

	1.	*2.*	*3.*	*4.*
Water @ 225°,	1.860	1.130	1.210	1.060
Volatile matter,	34.630	33.090	36.895	28.990
Fixed carbon,	47.304	53.006	52.593	35.588
Sulphur,	2.491	1.874	2.037	.977
Ash,	13.715	10.900	7.265	33.385
	100.000	100.000	100.000	100.000

	1.	2.	3.	4.
Coke per cent.,	63.510	65.780	61.895	69.950
Color of ash,	red.	gray.	reddish gray.	yellowish white.
Fuel ratio,	1:1.36		1:1.42	1:1.22

1. Coal from the Rock opening. The bed which has been drifted on at this opening occurs at the horizon of the Ferriferous limestone and is undoubtedly the representative of the Scrub Grass coal.

2. Coal from the Blue opening; Alton Upper bed.

3. Coal from the Hamlin opening. Top bench Alton Lower bed.

4. Coal from the Hamlin opening. Bottom bench Alton Lower bed.

Kinzua Creek Sandstone and Olean Conglomerate.

These two sandstones usually form the summit areas of the township outside of the coal basins and the crest of the hills along the third axis.

Except where the *Marshbury upper coal* has been opened or identified it is impossible to distinguish them as two separate strata. Neither their individual or combined thickness has been measured in the township, but in the adjoining township of Lumber, near the Cameron Coal Company's mine the latter thickness is between 120 and 130 feet.

In Shippen they partake of the general characteristics which distinguish them every where throughout the county. The Olean is conglomeritic and massive, while the Kinzua creek rock is a compact sandstone breaking up into rather thin plates.

One and a half miles east of Beechwood station on the P. & E. RR., the outcrop of the Olean is very prominent and characteristic. The hilltop is surrounded by a ledge 25′ to 30′ high of massive sand-rock and conglomerate while the slopes below are covered with broken fragments 10′ to 15′ in height. The rock consists of white quartzose, soft, coarse-grained sandstone, through which, parallel to the bedding, are layers from 1″ to 2″ thick, of white flattened pebbles. The soft sandstone has weathered away and left the pebbles exposed as ridges across the face of the blocks.

Although the sandstones are exposed only for 30 feet yet the hill slope up to the summit, a vertical distance of 35′, gives evidence of being underlaid by the same measures, for both on the slope and the summit above, small pieces of flaggy course-grained sandstone were seen. It is possible that the top is underlaid by a few feet of the KINZUA CREEK SANDSTONE.

Sub-Conglomerate Rocks.

The general character of these formations are the same throughout the whole country, and the general description of them already given will apply to Shippen as well as to the other townships.

The exposures of these rocks are here so much poorer than in the eastern part of the county that their respective limits could only be approximated to by noting the topography, the surface rock and the soil.

The Mauch Chunk red shale, No. XI, was in no place found outcropping or even coloring the soil red, but everywhere beneath the conglomerate cliffs, 40′ or 50′ of soft shaly measures were noticed. At this horizon in other parts of the county red and green shales were found, so that these soft rocks have been considered to represent No. XI. On the North creek road a short distance north of the McKean line the soil is colored intensely red by these shales.

The Pocono sandstone, No. X, forms the upper and steeper parts of the hill slopes, and cover the low summits and the crests of the hills along the third axis.

The Catskill, No. IX, occupies the valleys and extends up the hillsides, making more gentle slopes than the Pocono. Its limits in the township are shown on the geological map. In the western part it disappears near Beechwood Station on West creek, and near the county line up the Driftwood branch. The steep dips of the Boon's Mountain anticlinal bring it up in the beds of the main and east branches of Hick's run. It follows the whole length of the Portage creek in the township rising higher on the hills as the stream approaches its mouth. Two miles to the east of Emporium the steep dips of the Cameron basin carry it beneath the surface.

The area of the Chemung, No. VIII, as said before is confined to Shippen township.

From Emporium Junction it extends about 6 miles up West creek; 4 miles up the Driftwood branch; 4 miles up the Portage and less than 1 mile down the Sinnemahoning. The third axis brings it up again in the valley of the Portage at the county line.

The farm lands of the township are mainly in the Catskill and Chemung formations.

The character of such exposures as were noted is shown in the following sections:

Beechwood Section.

This section was observed on the hill north of the railroad 1½ miles east of Beechwood station.

Elevation of top of section *2,080* feet above tide:

1. Sandstone, soft coarse-grained, massive, containing layers of pebbles,	65′
2. Softer measures from bottom of sandstone to edge of steep slope,	50′
3. Concealed,	30′
4. Sandstone, olive-gray, gritty, thin-bedded; partially concealed,	30′
5. Concealed,	175′
6. Sandstone, olive-gray, gritty, thin-bedded,	5′
7. Concealed,	55′
8. Sandstone, olive-gray, gritty, thin-bedded,	15′
9. Concealed to railroad grade,	410′
Total,	835′

This section may be grouped thus:

Pottsville conglomerate, No. XII,	65′
Mauch Chunk, No. XI,	50′
Pocono, No. X, Catskill, No. IX,	720′

The hill is so covered with soil that it was impossible to find the top of the Catskill or indeed any trace of it, although since it goes under water level ½ mile west of Beechwood, there must be a considerable thickness of it in the above section. One mile east of the foot of this section, where the railroad crosses the wagon road near S. Sanford's house, 25′ to 30′ of greenish, fine grained sandstone is exposed. There is a thin band of red shale on top of the

exposure and the wash from it has colored the sandstone cliff slightly red. The strata show a northwest dip. These measures are undoubtedly Catskill and are near the bottom of the formation.

On the north bank of West creek, north of the railroad bridge, west of Beechwood, a few feet of green, micaceous sandstone, underlaid by red and green argillaceous shale is exposed. This outcrop must mark about the top of the Catskill, since as you approach the county line there are seen exposures of the characteristic Pocono sandstone.

Assuming the thickness of the Catskill in this portion of the township to be 340′, since at St. Mary's, Elk county, it is 335′, and at Cameron 347′, and since the distance between the disappearance of the Chemung and that of the Catskill is $2\frac{1}{2}$ miles, the rate of dip to the northwest would be 130 feet per mile. This estimate would place at least 200 feet of Catskill rocks in the Beechwood section.

West Creek section.

The following section was constructed along the road from West Creek station southeast to Wettimore's mill.

Elevation of top of section, 1810′ above tide.

1.	Concealed (from road summit,) gray soil,	50′
2.	Red and green shales exposed at intervals,	77′
3.	Sandstone, red,	3′
4.	Concealed, soil red,	25′
5.	Sandstone, green micaceous, flaggy, weathering red and green shales, exposed at intervals,	80′
6.	Concealed,	60′
7.	Sandstone green, micaceous flaggy,	1′
8.	Concealed,	254′
9.	Sandstone, olive flaggy, exposed at intervals,	45′
10.	Concealed to creek level, soil gray,	145′
	Total,	740′

This section may be grouped into formations as follows:

Pocono, No. X,		50′+
Catskill, No. IX,	exposed, 245′ / concealed, 105′	350′
Chemung, VIII,		340′+

The Pocono rocks extend up to the summit of the hill, high above the top of this section.

Stratum No. 6 seems to be the top of the Catskill, which is assumed to be of the same thickness as at Cameron, 350 feet. The exposures dip to the southeast.

This estimate would make 340′± of Chemung measures above the valley of West creek. The character of these rocks, where exposed along the county road, is shown in the following table:

Emporium to Beechwood.

Elevation.	Description.	Locality.
1031		Emporium station.
1035	Brittle, olive, argillaceous shales with bands of massive flaggy sandstone, 30′±.	West end of bridge over Driftwood branch at Emporium.
1045	Olive shales and sandstone, 15′	¼ mile beyond bridge.
1110	Olive shales and sandstone, of similar character to the above, 10′.	Near 145th mile post P. & E. R R.
1225	Massive greenish, fine-grained sandstone with thin band of red shale on top, 25 ± (Catskill, No. IX.)	At P. & E. RR. crossing, near 142d mile post.
1252		Beechwood station.

The following observations were made along the Driftwood branch from Emporium west:

Emporium up the Driftwood Branch.

Elevation.		Description.	Locality.
1031.	Chemung.		Emporium R.R. station, (Report N, p. 142.)
1095.	Chemung.	Olive shales and Flaggy S.S. 7′, dipping northeast.	East bank of North Creek at road croping.
1110.	Chemung.	Olive shales and S. S. on north bank of Main creek.	Bridge over Clear creek.
1125.	Catskill.	Red and green shales (Catskill).	Bridge over Driftwood branch, W. 2959.
1150.	Catskill.	Red shale.	Bridge over Deep creek.
1155.	Catskill.	Red shale.	Bridge over Driftwood branch, W. 2952.
1190.	Catskill.		Bridge over Fishing creek.
1355.	Catskill.	Red soil.	
1315.	Catskill.		Road near school house, W. 2348.
1300.	Catskill.	Red soil.	Rear school house.

In the Chemung exposures on the east bank of North creek, Judge Boynton of Emporium, reports that he found a gray iron ore.

On the Bond farm north of the junction of North creek with the Driftwood branch, Messrs. Houghston and Ernst drilled a well for oil, but no indications of oil were found.

The following is the record:

1. Conductor,	25′	to	25′
2. Shells, mostly fine sand,	200′	to	225′
3. Red rock,	12′	to	237′
4. Hard shells,	108′	to	345′
5. Red rock,	5′	to	350′
6. Shell,	75′	to	425′
7. Soft slate,	175′	to	600′
8. Sand,	55′	to	655′
9. Slate and shells,	295′	to	950′
10. Sand,	70′	to	1020′
11. Hard shells,	55′	to	1075′
12. Pebble sand,	4′	to	1079′
13. Soft slate,	250′	to	1329′
14. Sand shells and slate,	278′	to	1607′

Elevation of well 1100 feet above tide.

The top of the Chemung is probably 100′ above the mouth of the well, so that the section shows about 1,600′ of these measures. As stated in the general description of the Chemung rocks there is no stratum in this record which can be identified with the *Bradford oil sand*, since the horizon is 1,300 feet below the bottom of the Catskill rocks.

In warrant 2,952 near the mouth of Fishing creek this section was observed:

1. Partly concealed, loose, gray, flaggy sandstone,	190′
2. Sandstone, micaceous, flaggy thin-bedded,	20′
3. Concealed,	90′
Terrace,	—
4. Concealed,	125′
5. Soft green shales,	5′
6. Concealed to creek,	170′
Total,	600′

The upper portion of the section is undoubtedly Pocono, but it is impossible to determine the division line of the Pocono and Catskill. Stratum No. 5 resembles the shales of IX.

In warrant 2,348, south of the school house a Pocono covered summit 2,010 feet above tide was reached. The higher

points in this vicinity are covered with conglomerate, fragments of which are seen in the valley.

In the immediate vicinity of Emporium the exposures are so few and the dips of the Boon's Mountain and Kinzua-Emporium anticlinals so great and in all directions, that it was impossible to obtain the limits and thickness of the several formations.

The hilltops are capped by the thin-bedded sandstones of the Pocono; while the red wash from the Catskill shows in the hillsides.

On the hill east of the Junction the red wash from the Catskill shows in a pipe line trench for 370′ above the railroad. From this point to the summit, the hill slope is covered with fragments of the Pocono. There seems to be between 400′ and 500′ of the Pocono rocks still left on the summits. The thickness of the Catskill can only be estimated, but it can differ but little from the measurement in the Cameron well of 347′. In plate No. V in the Emporium section the thickness of these rocks is estimated at 350′.

On the hill north of the Emporium court-house at an elevation of 1,250 feet or 230′ above the Junction, loose pieces of an olive fine grained sandstone containing flat quartz pebbles were observed. This conglomerate resembles that found in the exposures of the Chemung along the Portage, and undoubtedly is of this formation. This would show that the Chemung in this vicinity is at least 230′ thick above water level.

The disappearance of the Chemung within a mile east of the Junction shows that the dip to the southeast is fully 300 feet to the mile.

The Chemung measures are exposed along the B., N. Y. & P. RR. north of the bridge over the Portage ½ mile from the Junction. They consist of gray and blue sandstones—conglomeritic—and green iron-stained shales. The sandstones are generally iron-stained and full of carbonaceous specks and plant remains. The conglomerates contain both quartz and slaty pebbles, while the slates often are made up of a mass of fucoid impressions. On the east bank of the Portage 1½ miles ± north of the Junction 30′ of alternating

sandstones and shales are exposed, dipping to the north at a rate of 10′ in 300′. The shales are greenish, much iron-stained, concoidal fracture and charged with iron. Judge Boyton of Emporium made an opening at this point in one of these shale bands in 1876. At the surface the band was 3 feet thick but diminished to 2½ feet as it advanced into the hill. On account of the dip being to the northeast into the hill the opening after being dug a few feet, was abandoned. Judge Boyton reports that Dr. Gregg of Elmira N. Y. analyzed the ore and found it to contain 28 per cent. of metallic iron.

The ore is low in iron and the band is so thin that it cannot be considered a commercial ore.

These rocks crop out along the Portage as far as Sizerville where they seem to go under water level, to reappear again at North county line. Some of these outcrops are noted in the following table:

Running Section from Emporium Junction to Keating Summit, Buffalo, New York and Philadelphia railroad.

Elevation.	Description.	Locality.
1019	. . . . .	Junction P. & E. RR. (Report N, p. 142.
1025	. . . . .	Road crossing ½ mile north of Junction.
1025	Massive, gray, fine grained, gritty, micaceous S. S., some layers containing flat pebbles, gray & green shales. Dip N. E.	Cut in bank on railroad at crossing.
1030	Exposures of same rocks, but more shaly.	200′± beyond cut.
1040	2′± hard, massive, fine-grained, Olive S. S., containing pebbles, underlaid by 15′± gray and green shales and slates.	500′± below bend to west.
1045	The above S. S. is here 4′± thick, the upper layer being full of small pebbles. Shales above and beneath.	Railroad at bend to the west.
1065 (?)	. . . . .	119th mile post 2 miles north of Junction.
1055	30′± of alternating hard, gray, massive S. S. with Conglomerate layers and green argillaceous fissile, iron-stained shales. Near center of exposure 2′± of red small pebble Conglomerate. Strong N. E. dip. (Chemung.)	East side of wagon road opposite J. Jackson's.

1090	. . . . .	Bridge over Portage, ½ mile south of H. Haven's.
1105	Olive and gray S. S. and shales, 8′ S. S. contains pebbles. (Chemung.)	On north bank of stream emptying into the Portage at H. Haven's.
1100	. . . . .	Bridge over Portage at 117th mile post.
1085	Gray S. S. and shales, containing in the center a reddish band 2′ thick. (Chemung.)	West bank of Portage above bridge.
1105	. . . . .	Oil well.
1110	. . . . .	Bridge over Portage S. W. corner W. 1407.
1140 (?)	Red soil in fields.	Railroad crossing below school house.
1185 (?)	. . . . .	Railroad crossing at Prestonville.
1201	. . . . .	Shippen station, B., N. Y. & P. RR. (Report N.)
1345 (?)	Cut 50′± in length through green and olive S. S. and shales. Dip 60° or more to S. E. 500′ to south the dip is about 4° or 5°. (Chemung.)	McKean county, 112th mile post.
1430 (?)	Olive, fine-grained S. S., green shales beneath.	One half mile north of 112th mile post.
1465 (?)	. . . . .	111th mile post.
1505 (?)	Olive gray, gritty S. S. containing small pebbles, 4′, underlaid by 10′± shales and shaly S. S.	South end of high trestling, McKean county.
	No perceptible dip. Greenish S. S. full of shell casts and pebbles. (Chemung.)	North end of trestling.
1565 (?)	. . . . .	Potter county, 110th mile post.
1680 (?)	. . . . .	109th mile post.
1790 (?)	Loose blocks coarse grained white quartzose S. S.	108th mile post.
1885 (?)	Olive S. S. and shales.	Railroad cut at Keating Summit.
1876	. . . . .	Railroad station, Keating Summit. (Report N. p. 149.) Potter county.

Dent's Run P. O., Benezette township, Elk county, to Beechwood Station, Philadelphia and Erie railroad Shippen township, Cameron county.

Elevation.	Description.	Locality.
905		Bridge over Dent's Run at mouth.
900	Red and gray thin-bedded S.S., .	Bridge over Hick's Run at mouth.
970	Gray slates and shaly S.S. dipping N. W.	2 miles above mouth.
995	Gray S.S., ...	Mouth of East Branch Hick's Run.

1015	Red and gray S.S. and shale 20′,	
1025	Gray shaly S.S. 10′ dipping N. W.,	
1085	Red and green shales and S.S.,	East Branch ½ mile N. of mouth.
1095	Red and green shales.	
1100	Green flaggy micaceous S.S., . .	Dam below junction of branch from the east—1 mile N. of main Branch Hick's Run.
1115	Greenish massive flaggy S.S., dipping N. W.	Branch from the east.
1120	Greenish massive flaggy S.S. 30′,	Above mouth of branch.
1150	Olive, gray and green S.S. 50′., .	"
1160	Olive gritty S.S., . . .	¼ mile above dam.
1175	4′ greenish flaggy S.S. overlaid by 2′ coarse quartzose S.S.	½ mile above dam near Cameron county line.
1210	Green flaggy S.S., ...	1 mile ± above dam.
1260	Olive gritty S.S. 3° S. E. dip, . .	2 miles ± above dam.
1275	Gray micaceous slates.	
1315	. . . . .	Dam—2 miles ± below Cochran's camp.
1375	Red and gray S.S. and shale—S. E. dip.	1 mile above dam.
1400	Red shale, ...	1½ miles above dam.
1450	. . . . .	Cochran's camp, 7 miles ± from mouth of Hick's Run.
1750	. . . . .	Hill N. E. of Cochran's camp on road to Howard's.
1730	. . . . .	Road on edge of slope to West Creek.
1161	. . . . .	Howard's siding P. & E. RR.
1252	. . . . .	Beechwood station P. & E. RR.

Drift.

At various points along the Portage and Sinnemahoning creeks beds of local drift were noticed.

The most marked one exists at a broad flat terrace, 35 to 40 feet above the stream, at the junction of the Portage with the Sinnemahoning. The drift is made up of rounded pieces of the local rocks from the Chemung to the Conglomerate, and contains no pebbles of an older origin.

Besides the Bond-farm well already mentioned several other wells have been drilled in the township, but with as little success.

Three of these are located in the Portage; one on the east bank east of Emporium Junction; and two near the mouth of Four-Mile run.

Salt has been obtained from wells along this creek.

254589

Chapter II.

Portage Township.

This township, the smallest in the county, lies directly east of Shippen. Its northern boundary is a portion of the Potter county line.

In its topography it resembles Shippen, being a highland carved out by the streams.

Its summits, on account of the north-east dips occasioned by the Kinzua–Emporium cross-flexure, are somewhat lower than those of the adjoining townships. The highest summit measured (there are probably higher ones) was *1930* feet above tide. The lowest point is about *980* feet above tide.

The greater portion of its surface is drained by the Sinnemahoning Portage and its tributaries, of which Cowley run is the largest.

The headwaters of Hunt's run rise in the southern part and drain a small area.

The extreme south-western corner is crossed by the main Sinnemahoning.

The township lies on the west side of the Third basin but contains little if any of the coal measures proper. The northeast dip of the Kinzua-Emporium cross-flexure together with the rapid rise of the Third axis has produced a depressed area or cross basin in the central portion of the township.

The elevation of the conglomerate in this basin near Shippen station is but *1910* feet above tide, while at Emporium, on the Boon's Mountain anticlinal, *the estimated elevation* of the same stratum would be *2400* ± feet, and at Keating station on the Third axis, in Potter county, *2400* feet. These elevations show a decided dip towards this central portion of the township. On account of this depression, the highest summits may contain the *Alton Coal group*.

The rock section extends from the upper part of the Chemung up to the Kinzua creek sandstone, and perhaps in some localities to the Johnson Run sandstone. The aggregate thickness is about 1000′±. The Kinzua creek sandstone, as stated before, is confined to the higher summits; the Olean conglomerate usually forms the hill tops, and the Pocono, Catskill, and Chemung occupy the hill slopes and valleys.

The Chemung enters the township from Shippen along the valley of the Portage and in less than a mile disappears below water level. From this point north the Catskill covers the valleys and a portion of the hill slopes.

It was impossible to measure the thicknesses of the formations in this township, since the exposures are of less frequent occurrence than in Shippen; with the exception of the valley of the Portage the township is a wilderness.

The Olean Conglomerate and the *Kinzua Creek Sandstone* are constant in their combined thickness of 120′.

The Mauch Chunk red shale is nowhere exposed, but is represented by the soft measures underlying the conglomerate.

The Pocono has the same features that characterize it in Shippen, consisting of thin-bedded and flaggy micaceous sandstones and grits. Its thickness here is unknown, but since this formation thins to the northwest (see plate), it is reasonable to believe that it is less than at Emporium and greater than at Norwich, at which places it is respectively 550′ and 300′. Its average thickness has been estimated as 470′.

The thickness of the Catskill is in doubt, as its limits could not be defined.

The northeast dip from Emporium carries the 300′ of Chemung exposed there beneath the surface five miles up the Portage. The average dip therefore would be 60′ per mile. According to this estimate there would be less than 100′ of Chemung measure exposed above water level in the township.

Shippen section.

East of Shippen Station on the Buffalo, New York and Philadelphia railroad, the following measurements were made:

Summit of hill *1940* feet above tide; sandstone, massive, gray, glittering coarse-grained, containing small angular and round pebbles,	20′
Interval, loose pieces of thin bedded sandstone,	270′
Sandstone, gray, gritty, flaggy,	1′
Concealed to railroad grade,	464′
Total,	755′

The rocks of the section may be grouped as follows:

Pottsville, No. XII,	20′
Mauch Chunk, No. XI,	45′
Pocono, No. X,	470′
Catskill, No. IX, (above water level,)	220′

Chapter III.

Lumber Township.

This township lies east of Shippen and east and south of Portage. The Potter and Cameron county line for three miles forms a portion of its northern boundary.

Hunt's run and a line prolonging its course to the southwest divide the township topographically into two portions; the comparatively low lands of the Cameron coal basin, and the high summits of the northwestern slope of the Rattlesnake anticlinal. This eastern portion of the township is more rugged than either Shippen or Portage. The valleys are deeper, the hills more precipitous, and the cliffs bordering the main creeks more frequent. The extreme eastern edge is a high divide separating the waters of the Sinnemahoning and the First Fork.

The greatest measured range of elevation is *1375* feet; from the lowest point, where the Sinnemahoning enters Gibson township, to the summit on the Kinzua–Emporium anticlinal in the southeast corner of the township.

The Sinnemahoning traverses the western part of the township; and with Sterling run on the west and Hunt's, Still-

house, Square Timber and several smaller runs on the east, drains the greater part of its area.

Logue's, Norcross, Mill, Brook's and Lick Island runs emptying into the First fork, head in the eastern highlands.

The Cameron coal basin crosses the extreme southwestern part of the township, and after passing through the corner of Shippen, occupies that portion north of Hunt's run

The Rattlesnake anticlinal runs through the southeastern corner and with the Kinzua-Emporium cross flexure elevates this portion of the township to over *2200* feet above tide.

The Kinzua-Emporium anticlinal passes diagonally through the central portion of the township in a northwest and southeast direction.

The rock section extends from the Catskill up to and including a portion of the Lower Productive coal measures, and has a maximum thickness of *1,190′* divided among the formations as follows :

Lower Productive coal measure,	100′±
Pottsville conglomerate No. XII,	200′±
Mauch Chunk red shale No. XI,	50′
Pocono Sandstone No. X,	550′
Catskill No. IX, (exposed)	290′
Total,	1190′

If to this we add the remainder of the Catskill (57′) and 511′ of the Chemung pierced by the Cameron well, the section becomes nearly 1750 in length.

The Productive Coal Measures.

The coal measures are confined to the Cameron basin in the western part of the township and will be noticed in detail in the chapter on the Cameron coal basin. They lie to the west of the Sinnemahoning between Sterling and Cameron stations, and west of the main branch of Hunt's run.

The rapid rise of the basin to the northeast and the presence of the Kinzua-Emporium anticlinal crossing diagonally the basin has elevated this portion much higher than that south of the Sinnemahoning, and consequently a less thickness of measures remain here.

Kinzua Creek Sandstone and Olean Conglomerate.

The combined thickness of these members of the Conglomerate series seems to be between 120′ and 130′.

About 125′ below the "Star" bed, one of the Alton coals, at the head of the Cameron Coal Co's plane a small coal bed is reported to exist. Since the Alton coals immediately overlie the Kinzua Creek Sandstone, and a coal bed is often found at the top of No. XI, this distance of 125′ would be about the thickness of these two sandrocks.

East of the Sinnemahoning and one half mile northeast of the Cameron Coal Co's plane at an elevation of *1495* feet, there is an old drift evidently on one of the lowest beds, probably the Star. Immediately below this there are loose pieces of conglomerate and sandstone.

Quarter of a mile to the west, and nearer the axis of the basin, there is an old drift evidently on the same bed, but at an elevation of *1475* feet. One hundred and twenty feet vertically below this bed a ledge was observed of compact pink and gray quartzose sandstone containing pebbles as large as a pea. Between the drifts and this point the steep slope contains loose pieces of coarse sandstone, while below the sandstone ledge loose blocks of the Olean are to be found.

This ledge evidently is very near the bottom of the conglomerate and would show the two sandstones to be about 120′ thick.

On all of the hill slopes east of the creek in this portion of the township the sandstones appear, the Kinzua creek as a coarse-grained, flaggy sandstone, and the Olean in massive blocks containing pebbles. These are their characteristics throughout the township.

At an elevation of *1440* feet above tide in the hill north of the Cameron Oil well, the Olean consists of a soft, friable, coarse-grained, ferruginous sandstone, containing small pebbles scattered through the mass.

Immediately north of Cameron Station this stratum has the same character. At an elevation of *1565* feet there is a bold outcrop 20′ high, of gray glittering, rather fine-grained quartzose sandstone, without pebbles. This is probably the Kinzua Creek Sandstone.

The summits east of the Sinnemahoning and southeast of Hunt's run are usually capped with the Olean; the Kinzua creek only underlying the highest.

One mile to the east of the main branch of Hunt's run at a point 3 miles from its mouth the Olean consists of a gray and white quartzose coarse-grained sandstone containing but few pebbles. The sandstone here breaks up into thin flat blocks, and is less massive than usual. The elevation of the bottom is *1800* feet above tide, or *745* feet above Hunt's run at the mouth of a branch from the east, one and a half mile southeast of this summit.

This elevation would show a resultant dip to the southwest to the Cameron well of 90 feet to the mile.

Sub-conglomerate Rocks.

The Mauch Chunk Shale No. XI was nowhere seen exposed in this township, but its horizon is marked in many places by the iron springs which define the bottom of the conglomerate. On both sides of the Sinnemahoning, northeast of Cameron station, as well as around the branches of Sterling run these springs are common.

On Hunt's run deposits of bog ore from this source are said to occur, but were not seen.

East of the Sinnemahoning in warrant 4033 near the Shippen township line, pieces of this lean siliceous ore of No. XI have been found.

The coal reported 125′ below the "Star" bed, Cameron Coal Co's incline, would be in No. XI, but could never be expected to be of any commercial value.

A slaty coal and cannelly slates occupy this horizon in Elk and McKean counties.

The Pocono, as generally throughout the county, forms the hill slopes and covers the low summit lands.

Its character is the same elsewhere in the county.

Between Cameron and the Sterling section a distance of 4 miles along the line of section (see plate) this formation thickens more rapidly than noticed anywhere else within the county limits. At the Cameron well the Pocono is 548′ thick while at Sterling it was found to be 660′ or an increase

of 112′ in the above distance. This is at a rate of 28′ per mile.

The average rate of thickening of the Pocono from Norwich, McKean county, to Sinnemahoning, a distance of 29 miles, is but 11′ per mile. From the Sterling section to Sinnemahoning, a little less than 7 miles southeast, the thickening is 60′, or less than 9′ per mile.

This thickening at a rate three times as great as that to the south seems to be local, as it has not been noticed elsewhere.

Whether the Catskill formation partakes of this more rapid increase of thickness between Cameron and Sterling we are unable to state, since the bottom of this formation is under water.

Although the bottom of the Catskill does not come above water level southeast of the Cameron basin, and so cannot be measured, yet the thickness of these measures above the lowest parts of the valley shows that there is a rapid increase of thickness.

From Smethport, McKean county, to Cameron, the Catskill thickens from 250′ to 347′, or at a rate of less than 4′ per mile. At Sterling 290′ of this formation occur above water level; at Driftwood on the crest of the anticlinal 500′; and north of Sinnemahoning on the flank of the Kinzua-Emporium axis 500′ and the bottom not reached.

These figures show at least a thickening of over 14′ per mile.

At Cameron station but 30′ of the formation is above water level, and within a half mile the northwest dip towards the center of the Cameron basin carries the top 113′ below the surface. The Kinzua-Emporium cross axis elevates these rocks in the valley of Hunt's run, so that they extend up the stream for three or four miles.

Good exposures of these rocks may be seen along the railroad and creek between Cameron and Sterling.

The Chemung nowhere in Lumber township comes above the surface; but its character for 500′ has been shown by the Cameron oil well. The details of the sub-conglomerate formations are shown in the following sections:

Cameron Well and Section.

This well, situated on the east bank of the Sinnemahoning one half a mile northeast of Cameron station, was drilled to a depth of 971′; but although one "sand" was pierced, it failed to produce oil.

The section was constructed in the steep hill immediately above the well. The elevation of the bottom of the Olean Conglomerate is *1440* feet above tide, and of the well mouth *955* feet.

	Massive sandstone and conglomerate. Lower portion of Olean, No. XII,	25′
	Concealed, (upper 50′± No. XI),	75
	Sandstone, green-gray, micaceous, thin-bedded,	10′
	Sandstone as above; grains a little coarse,	20′
	Concealed,	70′
	Sandstone, green-gray flaggy, thin-bedded,	5′
	Concealed to top of well,	305′
1.	Gray flags,	113′ to 113′

Catskill No. IX.

2.	Chocolate,	8′ to 121′
3.	Blue shale,	59′ to 180′
4.	Chocolate,	41′ to 221′
5.	Blue,	14′ to 235′
6.	Chocolate,	24′ to 259′
7.	Blue,	28′ to 287′
8.	Chocolate,	104′ to 391′
9.	Gray,	34′ to 425′
10.	Chocolate,	35′ to 460′

Chemung No. VIII.

11.	Gray,	120′ to 580′
12.	Dark iron gray,	9′ to 589′
13.	Light gray,	37′ to 626′
14.	Iron gray,	37′ to 663′
15.	Light gray, hard rock gas increasing,	84′ to 747′
16.	S. S. yellowish, very sharp grit,	42′ to 789′
17.	Light gray rock, large quantities of gas,	21′ to 810′
18.	Blue, soft, shelly, growing harder and whiter, then changing to brown rock, thence to blue,	64′ to 874′
19.	White,	20′ to 894′
20.	Red,	4′ to 898′
21.	Very hard blue rock,	73′ to 971′

The *Bradford oil sand* in McKean and Elk counties lies 1300′ below the bottom of the Catskill formation. To reach the horizon of this sand, provided the Chemung does not

thicken to the east as the formations above it do, this well would have to be drilled 800′ deeper.

Judging from the record of the Bond Farm well it seems improbable that this sand would be found at this depth.

Stratum No. 20 is one of a series of red bands which are very persistent in McKean and Elk counties. They show in the wells about Bradford, Kinzua creek, Wilcox, Ridgway, St. Mary's and other places in these counties.

In the vicinity of Sterling the Catskill outcrops in the hillsides showing a few exposures.

The outcrops of the Pocono are few. On the hill east of Sterling the following observations were made:

Hill east of Sterling.

Concealed,	25′
Sandstone, gray, thin-bedded,	5′
Concealed,	240′
Sandstone, gray, thin-bedded,	30′
Concealed,	240′
Sandstone, gray, thin-bedded,	5′
Concealed,	110′
Sandstone, gray, thin-bedded,	5′
Concealed,	60′
Interval, red soil down to creek 25′± of red sandstone exposed at bottom,	290′
Total,	1010′

This may be grouped into formations as follows:

Mauch Chunk No. XI, Pocono No. X,	720′
Catskill No. IX,	290′+

Tanner section.

From Sterling south to G. W. Tanner's house in warrant 5468 Gibson township this section was observed:

1. Coarse-grained conglomeritic sandstone, Olean No. XII,	20′
2. Interval, red and green shales at bottom,	50′
3. Concealed,	40′
4. Sandstone, blue-gray, gritty flaggy, with a thin band of coarse quartzose iron-stained sandstone,	20′
5. Concealed,	30′
6. Sandstone, green-gray, micaceous flaggy, exposed at intervals,	40′
7. Concealed,	60′

8.	Sandstone, olive-gray, gritty, flaggy, micaceous,	20′
9.	Sandstone, gray, gritty, flaggy exposed at intervals,	90′
10.	Concealed,	65′
11.	Sandstone and shales, green, with thin band of red at top,	20′
12.	Concealed,	150′
13.	Red shale,	5′
14.	Concealed,	50′
15.	Sandstone, gray and green, gritty, flaggy,	20′
16.	Concealed,	50′
17.	Sandstone and shales, red and green exposed at intervals down to creek,	290′
		1020′

Grouped as to formations:

Pottsville conglomerate No. XII,	20′
Mauch Chunk No. XI,	50′
Pocono No. X,	660′
Catskill No. IX,	290′+

The Pocono in stratum No. 8 is quite massive the flags varying in thickness from 1′ to 2″.

The band of quartzose sandstone in No. 4 is compact, but less than 1 foot thick.

From Cameron up Hunt's run the observations given in the table below were made:

Cameron Station, Philadelphia and Erie railroad to S. E. corner W. 5442.

Elevation.	Description.	Locality.
962	Red S. S. and shale.	Railroad station.
1105	Green, micaceous, flaggy S. S. and red shale.	Road S. W. corner W. 5443.
1085		Junction of branch from the east with Hunt's run.
1640	Olive flaggy S. S.	On hillside between forks of stream, W. 5442.
1830	Gray, massive, glittering, coarse-grained S. S.	Summit S. E. corner, W. 5442.

Chapter IV.

Gibson township.

Gibson, the second township in point of size, lies south of Lumber and east of Benezette township, Elk county.

Its south line is a portion of the Clearfield county line.

The Sinnemahoning creek with a winding but general southeasterly course, flows through the northeastern part of the township. At Driftwood it receives the waters of the Bennetts branch which, entering the township from Elk county has a course a little south of east through the north central part.

The Sinnemahoning drains but a limited area, mainly that portion of the township to its northeast. Its tributaries with the exception of Bennetts branch are small streams of but from two to six miles in length.

Bennetts branch receives but one large tributary—Hicks run—from the north. This latter stream rises in eastern Elk and the southwestern part of Shippen township, cuts across the Boon's Mountain anticlinal, crosses the northeastern corner of Benezette township, Elk county, and empties into Bennetts branch just east of the Gibson township west line.

The remainder of the tributaries from the north are few in number and less than three miles in length.

Mix run, its largest tributary in the township, rises in the southern part of Benezette township, and after draining a large area, flows for 2½ miles through Gibson township before emptying into Bennetts branch. Red run and a few small branches of Mix run drain that portion of the township west of the Lincoln road.

The greater part of southern Grove is traversed and drained by Wykoff and Upper Jerry runs which empty into the Sinnemahoning in Grove township.

The headwaters of a few streams flowing into the West Branch of the Susquehanna, rise along the south line.

North of the Bennetts branch the topography is characterized by the steep cliff covered slopes and sharp and irregular summits of the Pocono. This portion of the township is so cut up by small streams that the area covered by the conglomerate is small.

The Sinnemahoning and Bennetts branch flowing through the winding channel, in many of the sharp turns expose perpendicular cliffs of the massive red and green sandstones of the Catskill. The valleys of these main streams are often 1000′ to 1200′ below the summit lands.

South of the Bennetts branch the summits are broad and flat, areas characteristic of the land capped by the conglomerate.

The range of elevation within the limits of the township is 1450′ from the lowest point of Sinnemahoning, 780 feet above tide, to the summits in the northeastern corner, some 2225 feet above tide.

The Driftwood anticlinal traverses the central part of the township in a northeast and southwest direction, passing through Driftwood Junction. Its northwest and southeast dips are here shown in the railroad cuts to the north and south of Driftwood.

The exposures along the Bennett's branch for a mile southwest of its mouth show that the crest of the axis declines as it goes south.

The northern part of the township lies in the Third Basin, but the coal measures are only caught in the very northwestern corner; and probably no coals higher than the Alton group still remain there.

That portion of the township southeast of the Driftwood anticlinal lies in the Second Bituminous Basin, but as far as now known, contains no productive coal measures. The conglomerate everywhere seems to be the surface rock.

The Marshburg upper coal may be present between the Olean Conglomerate and the Kinzua Creek Sandstone, but it can hardly be considered a commercial bed.

The rock section exposed extends from 500′ below the top

of the Catskill up to the coal measures of the Cameron basin, and has a total thickness of about 1450′.

The thicknesses of the formations are:

Pottsville conglomerate, No. XII,	200′±
Mauch Chunk shale, No. XI,	50′
Pocono, No. X,	685′
Catskill, No. IX,	500′

The description of the coal measures of the conglomerate series will be found in the chapter on the Cameron Coal Basin.

Kinzua Creek Sandstone and Olean Conglomerate.

As stated before, north of the Bennett's branch, only the high summits are capped by these measures; but to the south they are the surface rocks. Their general character is the same as everywhere throughout the county. The details of the exposure, where observed, will be given in the description of the various sections.

Sub-conglomerate rocks.

One and a half miles south of Sterling and 50′ below the bottom of the Olean conglomerate the soil is colored red by the shales of No. XI; while one mile further south and the same distance below the conglomerate, green argillaceous shales were observed.

The only other place in the township where these shales and the red soil were seen is on the Karthaus road where it crosses the township line.

The terrace formed by these softer measures under the conglomerate is, however, prominent everywhere.

The Pocono thickens slightly in the township, increasing from 660′ at Sterling to 685′ at Driftwood and 720′ near Sinnemahoning. This formation is the surface rock of the greater part of the township north of the Bennett's branch, and shows in prominent cliffs on the hill slopes.

The Catskill, following the stream-courses often exposed in massive cliffs, forms the valley lands of the township. The greatest thickness exposed above the surface is at Driftwood where the anticlinal elevates 500′ of it above water level.

To the north of Sinnemahoning P. O. about this same thickness is brought to view by the Kinzua-Emporium cross-anticlinal.

How much of the Catskill exists beneath the surface, it is impossible to state since no wells have been drilled through it in this part of the county, and since it does not come above the surface until the neighborhood of Lock Haven, Clinton county, is reached in descending the West Branch.

Driftwood section.

This section was constructed on the hill directly west of the Driftwood railroad station.

The summit is *2025* feet above tide, or *1210* feet above the railroad :

1. Concealed, (Mauch Chunk No. XI),	40′
2. Sandstone, olive, thin-bedded,	5′
3. Concealed,	20′
4. Sandstone, olive, thin-bedded,	5′
5. Concealed,	25′
6. Sandstone, olive, thin-bedded,	5′
7. Concealed,	40′
8. Sandstone, olive, close-grained,	35′
9. Sandstone, gray, thin-bedded,	10′
10. Concealed,	90′
11. Sandstone, gray, thin-bedded,	10′
12. Concealed,	160′
13. Sandstone, gray, thin-bedded,	20′
14. Concealed,	15′
15. Sandstone, olive-gray, very thin-bedded,	75′
16. Concealed,	60′
17. Sandstone, olive-gray, flaggy with thin band of red shale at top,	30′
18. Sandstone, red and gray, thin-bedded,	20′
19. Concealed,	25′
20. Sandstone, red, thin-bedded,	10′
21. Concealed,	25′
22. Sandstone, gray, thin-bedded; weathers red,	70′
23. Concealed,	25′
24. Sandstone, gray, thin-bedded,	25′
25. Concealed,	20′
26. Sandstone, gray and red, micaceous,	30′
27. Sandstone, red, micaceous,	15′
28. Sandstone, olive-gray, gritty,	30′
29. Sandstone, red and gray, thin-bedded,	50′
30. Concealed,	20
31. Sandstone, red, micaceous, gritty,	25′
32. Concealed,	15′

33. Sandstone, green and red, micaceous,	10′
34. Concealed,	40′
35. Sandstone, green, micaceous, massive,	10′
36. Sandstone, green and red, massive, with bands of red and green shales,	115′
Total,	1225′

This section may be grouped as follows:

Mauch Chunk, No. XI,	40′+
Pocono, No. X,	685′
Catskill, No. IX,	500′+

The Olean conglomerate is not found in place on this hill, but small fragments still remain on the highest point. It is questionable whether the first interval, 40 feet in thickness, should be assigned to the Mauch Chunk or the Pocono. On account however of the thickness of the Pocono as measured in the same vicinity, and the presence of the remnants of the Olean, showing that its bottom must have been but little higher, it was thought best to consider this interval as a part of No. XI.

In plate — the remaining portion of No. XI and 20′ of the *Olean*, as found on the neighboring hilltops, has been added.

The upper portion of No. IX and the lower portion of No. X resemble each other very closely, the only difference being the predominence of red in the former.

The majority of the intervals marked "concealed" contain undoubtedly the same character of strata as overlie and underlie them; and if the section had been made in other parts of the hillslope they would be found to contain exposures. The greater part of the lowest interval (No. 36) was measured in the railroad cut at the east end of the Driftwood yard. The green sandstones are in layers, sometimes 3′ or more in thickness, alternating with massive red micaceous sandstone, and red and green argillaceous shales. The wash from the red shales has given a reddish color to the surface of the green sandstones.

During the war of 1812 a salt well 65′ deep was drilled at a natural lick on the creek bank one half a mile below the railroad station at Driftwood. Salt was manufactured here from 1815 to 1819 in 90 gallon potash kettles by the Lycoming Salt Company and was sold to the local trade.

The salt obtained in the well on the Portage in McKean

county just north of the Cameron line comes from the Chemung rocks, but whether the Driftwood well pierced these rocks or stopped in the Catskill is not known.

Trump's Hill section.

The following partial section was constructed along the Lincoln road, from Driftwood to the Trump farm. Summit of section is *2095* feet above tide:

1.	Massive sandstone and conglomerate,	75′±
2.	Concealed,	175′
3.	Sandstone, olive-gray, thin-bedded, exposed at intervals,	20′
4.	Sandstone, massive, olive-gray, fine-grained, partially exposed,	40′
5.	Interval with two thin red bands near center,	160′
6.	Sandstone, olive-gray, fine-grained, massive, exposed at intervals,	90′
7.	Concealed,	120′
8.	Sandstone, olive-gray, thin-bedded, micaceous, exposed at intervals,	70′
9.	Concealed,	45′
10.	Sandstone and shale, red and green, exposed at intervals to creek,	500′
	Total,	1295′

This may be grouped as follows:

Pottsville conglomerate, No. XII,	75′±
Mauch Chunk, No. XI, Pocono, No. X,	725′
Catskill, No. IX,	500′

The Olean conglomerate here consists of a gray and white coarse-grained sandstone containing pebbles as large as a hazelnut. Large blocks with rectangular faces cover the hillslopes.

The surface immediately beneath the conglomerate is so drift-covered that it was impossible to determine the limits of No. XI. The thickness of No. XII can differ but little from that given in the section.

The red bands in interval No. 5 show, by coloring the soil in the roadside, and are of little thickness.

The character of the Pocono in the cuttings in the road, is much more massive than in the natural exposures.

The exposures of the Catskill are few and thin, but the soil for the height given in the section is of a red color and contains pieces of red shale.

The following tables contain the barometric elevations of summits, stream crossings and other prominent points in the township, together with the location, elevation and description of outcrops:

Driftwood to Summit in warrant 5425 Lumber township.

Elevation.	Description.	Locality.
815	. . . . .	Driftwood Station P. & E. RR.
845	. . . . .	Stream crossing, Huntley road, 1 mile from Driftwood.
845	Massive red and gray sandstone and red shale, 25′±.	At RR. bridge below Huntley.
855	. . . . .	Railroad at Huntley.
1420	Red shale, ...	Up Dry run.
1530	Greenish sandstone, . . .	" "
2110	Loose pieces, thin, flaggy sandstone.	Top of hill broad, flat. 2½ miles± from Huntley.
2115	Loose, gray, glittering, coarse-grained sandstone, (No. XII.)	Farm house to west of road.
2270	Thin plates, coarse-grained sandstone.	Summit northwest of house.
2225	Flat blocks of coarse-grained gray, glittering sandstone. Some conglomerate.	Road summit near farm.

Warrant 5468, Gibson Township, Cameron County, to Dent's Run, Benezette Township, Elk County.

Barometric Elevation.	Description.	Locality.
1920	Large blocks massive coarse-grained sandstone and conglomerate.	School house, W. 5468.
1880	Green argillaceous shales. (No. XI.)	Turn of road S. E. corner W. 5468.
1490	Olive and gray shaly sandstone.	Near turn in road S. W. corner W. 5468.
1440	Gray, gritty sandstone, ...	Turn in road S. W. corner W. 5468.
1285	Greenish shales, ...	½ mile N. E. of W. Barr's.
985	Red shale. (No. IX.) . . .	W. Barr's, W. 5474.
945	Gray shaly sandstone in run bed.	" "
915	Gray, thin-bedded sandstone, weathering red.	Junction with Driftwood road.
900	Red and gray thin-bedded sandstone, 8′±.	Bridge over Hick's run.
905	. . . . .	Bridge over Dent's run.
926	. . . . .	Dent's Run station, A. V. RR.

From Benezette to Driftwood these observations were made along the county road.

Benezette to Driftwood.

Barometric Elevation.	Description.	Locality.
1040	. . . . .	Benezette station, Bennett's Branch Extension R R. (Report N, p. 186.)
1000	Gray shales and massive sandstone, containing bands of red and green shales, 40′±. Dip N. W. (No. X.)	North end of bridge to Benezette RR. station.
975	. . . . .	Road to N. W. 2½ miles from Benezette.
950	Red shale. (No. IX.)	In creek bottom near J. S. Johnson's, Warrant 5023.
1020	A little red shale, ...	On hillslope beyond junction of roads, Warrant 5023.
970		
1000	Red shale 4′, ...	Road opposite Grant station.
1030	Gray sandstone.	
1020	Red sandstone, ...	Road ¼ mile below Grant's.
920	Red shale and sandstone, 20′±,	
905	. . . . .	Bridge over Dent's run.
900	Red and gray sandstone in bank.	Bridge, Hick's run.
915	. . . . .	W. Barr's, W. 5474.
965	Red shale and sandstone.	
1020	Red shale.	
950	Red shale, 20′. N. W. dip, . .	Opposite mouth of Mix run.
816	. . . . .	Driftwood station, P. & E. RR.

Driftwood to Lincoln to Benezette.

Barometric elevation.	Description.	Locality.
816	. . . . .	Driftwood Station P. & E. RR.
2045	Gray, glittering, coarse-grained sandstone.	Road at Trump's.
2095	. . . . . Gray, glittering, coarse-grained sandstone.	Road on Ridge 1000′± S. of Trump's.
2035	. . . . .	Junction of roads 7 miles from Driftwood.
1975	Coarse, gray, glittering sandstone.	On descent to Red run.
1935	. . . . .	Bridge over Red run.
1975	Loose sandstone, ...	House at Lincoln.
2085	Sandstone and conglomerate, .	Ridge 3 miles west.
2130	Large blocks of sandstone, . .	4 miles± west of Lincoln.
2025	Pea conglomerate, ...	Old camp.
2040	. . . . .	Head of Mix Run.
1925	. . . . .	Ridge 2 miles from Barr Station.

1765	Terrace, covered with large blocks of sandstone.	1 mile from Barr's.
1030	Red shale and gray sandstone.	Road at Barr's.
1040	Gray and red shales and sandstone.	Benezette Station.
		Bennett's Branch Extension RR. (Report N, p. 186).

Sinnemahoning down Karthaus road to county line.

Elevation.	Description.	Locality.
794	. . . . .	Sinnemahoning Station.
2040	Gray, coarse-grained, glittering sandstone.	Top ridge 2½ miles south of station.
1975	Large blocks of coarse, gray, soft, glittering sandstone, much weathered.	Panther rocks 4 miles from Sinnemahoning.
2030	. . . . .	Main ridge 1 mile south of Panther rocks.
2055	Blocks of gray, glittering sandstone.	Knob, west of road, 8 miles from Sinnemahoning.
2160	Gray, coarse-grained, conglomeritic sandstone. Pebbles as large as pigeons' eggs.	Ridge at county line.
1900	. . . . .	Bridge over Three runs.

The elevations of the conglomerate at the above points show that this formation rises towards the south. The cause of this, whether a cross-flexure similar to the Kinzua-Emporium axis or a sub-anticlinal between the First and the Second axis can only be determined by a survey of northern Clearfield county. The sandstones seem to be, judging from their character, confined to the Olean and Kinzua Creek strata.

No coal has been found in this portion of the township.

Chapter V.

Grove township.

Grove lies to the east of Lumber and Gibson and occupies the eastern part of the county. Potter bounds it on the north, and Clinton on the east and south.

The summit lands rising 1000′ to 1500′ above the main valleys are flat, broad and usually underlaid by the conglomerate measures. The hill slopes are steep and drift covered. The greatest difference in elevation measured in the county is 1500′ from the lowest point, where the Sinnemahoning crosses the Clinton line at an elevation of *760′*± above tide to the highest—a summit at the headwaters of Arksill run *2260* feet above tide.

The Sinnemahoning enters the township at Sinnemahoning station and flows four miles in a southeast direction before it enters Clinton county. The hills bounding its narrow valley are steep and rugged with outcropping rocks.

With its branches it drains all of the township with the exception of a few small areas in the south corner which empty into the West Branch of the Susquehanna.

From the south it receives the drainage of a large portion of Gibson township through the channels of Wykoff and Upper Jerry runs. These two streams together with Middle and Lower Jerry runs drain this portion of the township.

The greater portion of the area is tributary to the First Fork which empties into the main stream at Sinnemahoning. This branch rises in the high summit lands of Potter county and enters Cameron as a large stream. It first flows southeast for some six miles and then bends abruptly to the west and flows for seven miles in a course a little west of south. It receives numerous tributaries of a few miles in length, from each side.

Grove township, excepting the northwest corner, lies in

the Second Bituminous basin, but so far on its western slope that it fails to include any of the coal measures. As in a great part of the county, the poor slaty coal between the Kinzua creek sandstone and the Olean conglomerate may exist, but its character is such as to make it of but little value.

The northwest corner above referred to lies in the Third Bituminous basin on the west slope of the Rattlesnake anticlinal.

The Driftwood anticlinal after crossing the Sinnemahoning at the mouth of Bennetts branch, continues its north east course into Grove township. Near Lick Island run it appears to make a break to the west of about four miles.

From the high lands in southeastern Lumber township it again takes a northeast direction through Grove and crosses the First Fork near Rattlesnake run. Near this point southeast dips in the red measures of the Catskill can be seen on the east bank of the First Fork.

The Kinzua-Emporium axis runs diagonally through the township in a northwest and southeast direction, crossing the First Fork near the mouth of Lick Island run.

The dips of this axis in Grove township, as stated are very marked. Although no pronounced dip is apparent in the exposures along the First Fork, yet the elevation of the conglomerate on the summits show that from Sinnemahoning to the crest of the flexure, near the headwaters of Arksill run there is a rise of some 66′ to the mile.

The elevation of the bottom of the Olean at Ellicott's run is *2050* feet above tide, and at the head of Arksill run there is a summit containing no conglomerate measures, *2250* feet above tide. South of Ellicott's run to the summit on the Karthaus road near the township line the fall is less, only being 40′ to the mile.

The elevations of the bottom of the conglomerate at Houselog run *1915* feet, and at Bailey run *1880*± feet, show that the northeast dip decreases from over 100′ per mile between the crest and the former point, to less than 20 feet per mile between these two points.

The effect of this cross-flexure seems then to have been to raise an elevated northwest and southeast ridge across the

township and to have formed a parallel depressed area to the north.

The rock section exposed in the township extends from the Catskill up to the Conglomerate Measures, and has a thickness of 1410 divided among the several formations as follows:

Pottsville Conglomerate, No. XII,	115′±
Mauch Chunk shale, No. XI,	50′
Pocono, No. X,	745′
Catskill, No. IX,	500′

Kinzua Creek Sandstone and Olean Conglomerate.

These sandstone measures underlie the summits generally throughout the township, forming a prominent escarpment around the hilltops. They can be observed in all of the hills about Sinnemahoning, the Olean or lower member outcropping in cliffs 30′ or more in height, while on the summits the thin blocks of the Kinzua Creek Sandstone are found.

The Olean is a massive coarse gray and white sandstone, sometimes iron stained, containing bands of pebbles. The Kinzua Creek, as usual, is much thinner bedded, and less conglomeritic. The greatest thickness of these sandstones measured in the township is 115′.

Sub-conglomerate Rocks.

The Mauch Chunk Shales, No. XI, form a gently sloping terrace between the bottom of the conglomerate cliffs and the steep slopes underlaid by the Pocono. These terraces are so covered with the wash from the higher measures, that but in few places are the red and green shales exposed.

On the Karthaus road at the township line, pieces of green argillaceous shales whose wash colors the soil red, occur in the bank. On an old log road north of the mouth of House-log run the soil is colored slightly red by these shales.

The iron ore of No. *XI* accompanies the formation in this township, but is very lean. On the House-log run hill small pieces of this ore were found. At the headwaters of

Pepperhill run, the soil is reported to be intensely iron stained by springs from this bed.

The Pocono No. X, forms the upper part of the hills, and covers the low summits, and some portion of the crests of the anticlinals.

Its thickness seems to be very uniform, the extreme limits as measured being 720′ at Ellicotts run and 743′ at Bailey run. It consists of thin-bedded, gritty, olive and gray sandstones, interstratified with beds of green argillaceous shale. A few calcareous beds have been found, but of too sandy a a character to be of any value as a fertilizer.

One bed of black coaly slates, probably a representative of one of the coal beds described by Mr. Ashburner in Report F as occurring in the Pocono, has been opened on Ellicott's run.

The Catskill No. IX, forms the bottom and arable lands of the valleys.

Exposures of the massive red and green sandstone, composing its lower part occur along the banks of the Sinnemahoning and the First Fork. Fine exposures along the latter stream occur near its mouth on the west bank, and in the sharp bend some six miles above.

The thickness of No. IX above water level, varies from 200′ in the northern part to 500′ in the vicinity of Ellicott's run on the flank of the Kinzua-Emporium anticlinal. What the total thickness is we have no data from which to even make an estimate.

The details of the above formations are given in the following sections:

Karthaus road section.

1. Sandstone and conglomerate,	115′
2. Interval, with green shales and red soil,	40′
3. Interval, with exposures of thin-bedded, gray and olive sandstone,	725′
4. Red and green sandstone and shale exposed at intervals, . sandstone and shale, green and red,	300′
5. Massive sandstone, interstratified with thin bands of red and green shale,	100′
Total,	1280′

The formation thicknesses are:

Pottsville conglomerate, No. XII, ... 115′
Mauch Chunk shale, No. XI, ... 40′
Pocono, No. X, ... 725′
Catskill, No. IX, ... 400′

The summit of this section, *2040′* feet above tide, is about three miles south of Sinnemahoning station.

The upper part of the sandstone is coarse grained and quartzose but rather flaggy, breaking into slates a few inches in thickness. This portion is evidently the KINZUA CREEK SANDSTONE.

The lower part is more massive and contains pebbles.

The 40′ of soft measures beneath the conglomerate represent No. XI.

The thickness of this formation may be 10′ or 15′ more on account of the dip to the south, but this difference would be covered by the limit of error of the barometric measurement.

Ellicott's Run section.

This section was constructed in the bed of the run and on the hill between it and the First Fork.

The elevation of the top is *2050* feet above tide.

1. Sandstone and conglomerate, (OLEAN), ... 60′
2. Concealed, ... 50′
3. Sandstone, gray, thin-bedded, ... 5′
4. Partly concealed, sandstone gray and flaggy, ... 120′
5. Concealed, ... 80′
6. Sandstone, gray, micaceous, thin-bedded, ... 10′
7. Concealed, ... 45′
8. Sandstone, gray, gritty, thin-bedded, ... 10′
9. Concealed, ... 120′
10. Sandstone, gray, gritty, thin-bedded, ... 30′
11. Partly concealed, sandstone, gray, flaggy; red shale band at bottom, ... 105′
12. Sandstone, gray, thin-bedded, ... 10′
13. Partly concealed, red shale near center of interval, . . . 45′
14. Sandstone, gray, thin-bedded, micaceous, ... 5′
15. Brown slates, ... 2′ 6″
16. Black carbonaceous slates full of stem impressions, . . 3′ 6″
17. Concealed, ... 10′
18. Sandstone, gray, flaggy, ... 10′
19. Concealed, ... 34′
20. Sandstone, gray, gritty, thin-bedded, calcareous bands, . 30′
21. Sandstone, gray, thin-bedded, ... 50′
22. Sandstone, red and green, micaceous, thin-bedded, . . . 40′
23. Concealed, ... 30′

24. Sandstone, gray and green, flaggy,	10′
25. Partly concealed, sandstone and shales; red and green, Sandstones in lower part massive,	420′
Total,	1335′

This may be grouped as follows:

Pottsville conglomerate, No. XII,	60′+
Mauch Chunk shale, No. XI,	50′
Pocono, No. X,	725′
Catskill, No. IX,	500′±

Stratum No. 7 consists of gray and yellow coarse-grained sandstone, with ridges of iron oxide running through the mass. Some of the sandstone contains white and round quartz pebbles as large as peas. Blocks 15′ or more in height cover the flat at the foot of the ledge.

No red shale or iron wash was seen in the interval of 50′ beneath the conglomerate, as the débris from the conglomerate covers the terrace.

The concealed intervals in the Pocono are covered with the broken flags of this formation and undoubtedly are underlaid by the same sandstones as exposed above and below them.

The stratum of black slates, No. 16, was opened on the east branch of Ellicott's run 1¼ miles from Sinnemahoning in 1877 in hopes that it would develop into a coal bed, but after digging into the hillside for about 4′ the drift was abandoned.

The slate contains impressions of plant stems, and in every way resembles the slates of the Bituminous coal measures. The opening is about *670* feet above the mouth of the run, and 580′ below the bottom of Olean conglomerate. Nowhere else in the county is it known to have been discovered. This, as stated before, may be the representative of one of the coal beds of the Pocono described in Report F as found in Sideling Hill Tunnel, Huntingdon county.

Near the mouth of Ellicott's run, in the river drift on the east bank of the First Fork, a blue clay is found, which is reported to make good pipes. It has been used by the local blacksmiths for moulds in which to make copper cowbells.

The extent of the deposit has never been tested, so that

it is not known whether it exists in any quantity or is a mere streak in the drift.

The following observations were made on the road from Sinnemahoning to Cook's run, via Ellicott's run.

Barometric elevation.	Description.	Locality.
780	. . . . .	Sinnemahoning hotel.
2070	. . . . .	Flat at head of Ellicott's run.
2120 to *2170*	Ledge of coarse-grained, white and yellow sandstone and conglomerate, some layers 2′ to 3′ in thickness. The round and angular pebbles in the conglomerate vary in size from a small pea to a hazelnut.	200′ west of the road.
2240	. . . . .	Highest point on road near descent towards Montours run. Loose sandstone and conglomerate in road. Main ridge 20′± higher.
2190	. . . . .	"Jack Bell's Rock." Conglomerate ridge higher than this.
2140	This point is below the conglomerate.	Divide between Arksell and Montour runs.
2260	Olive, micaceous, flaggy sandstone resembling the Pocono.	Ridge between Montour and Cook's runs.

The last-mentioned point in the above table seems to be near the crest of the Kinzua-Emporium anticlinal, and it would seem as if this axis had carried the conglomerate above this elevation.

Ascending the valley of the First Fork, outcrops of the Catskill massive red and green sandstones are frequent, while the cliffs of the Pocono and loose blocks of conglomerate are seen on the hill slopes.

At the sharp bend near the mouth of House-log run, warrant 4152, vertical cliffs of the red and green sandstones of the Catskill are exposed on the west bank of the First Fork. Above the sandstone the ledges of the Pocono are seen.

The following section was observed in the hill north of House-log run:

House-log run section.

1. Pea conglomerate and massive, coarse-grained sandstone, (Olean No. XII), ... 45′
2. Interval, with red soil and small pieces of iron ore, (Mauch Chunk No. XI), ... 50′

3. Sandstone, greenish-gray, micaceous, thin-bedded,	3′
4. Concealed,	102′
5. Sandstone, greenish-gray, flaggy, top thin-bedded,	45′
6. Green argillaceous shale,	5′
7. Sandstone, greenish-gray, micaceous, flaggy,	78′
8. Sandstone, brown, quartzose, very compact,	2′
9. Sandstone, green, flaggy,	10′
10. Green shales,	25′
11. Sandstone, green, micaceous, slaty,	10′
12. Sandstone, green, massive, flaggy, micaceous,	40′
13. Concealed,	133′
14. "Spirifer band,"	2′
15. Sandstone, green, flaggy, micaceous,	20′
16. Concealed,	45′
17. Sandstone, green, gritty, flaggy, with a little red shale,	5′
18. Sandstone, green and gray, flaggy, thin-bedded, exposed at intervals, containing three thin bands of red shale,	215′
19. Red argillaceous shale,	20′
20. Sandstone, green and red, massive, with bands of red and green shales, down to creek, 870′ above tide,	235′
Total,	1090′

This section may be grouped as follows:

Pottsville conglomerate, No. XII,	45′
Mauch Chunk shale, No. XI,	50′
Pocono, No. X,	740′
Catskill, No. IX,	255′

The Pocono strata are exposed in the log slide on this hill, and the Catskill in the hill south of the run.

The "spirifer band" stratum No. 14 is a mass of shells from which a great part of the lime has been leached out, leaving a soft dark iron stained mass, still showing the skeletons of the shells.

The Pocono where brought to the surface by the removal of the surface drift is more massive than in the cliffs on the surrounding hills.

On the hill between the First Fork and Bailey run, and north of the latter this section was measured:

Bailey run section.

Elevation of summit 1905′ feet above tide.

1. Conglomerate and sandstone, Olean No. XII,	25′
2. Concealed to change of slope,	50′
3. Concealed,	90′
4. Sandstone, gray, thin-bedded,	5′
5. Concealed,	40′

6. Sandstone, gray, thin-bedded,	15′
7. Concealed,	60′
8. Sandstone, gray and olive, thin-bedded,	80′
9. Concealed,	10′
10. Sandstone, gray and olive, thin-bedded, micaceous,	80′
11. Concealed,	60′
12. Sandstone, gray, thin-bedded, micaceous,	20′
13. Concealed,	40′
14. Sandstone, gray and olive, thin-bedded, micaceous,	160′
15. Concealed,	55′
16. Sandstone, gray, thin-bedded, gritty,	30′
17. Concealed, (probably red shale and sandstone),	180′
18. Sandstone, massive, green and red, down to creek,	30′
Total,	1030′

This thickness seems to be distributed among the several formations as follows:

Pottsville conglomerate, No. XII,	25′
Mauch Chunk shale, No. XI,	50′
Pocono, No. X,	745′
Catskill, (exposed), No. IX,	210′

The hill top is capped by a ledge of the characteristic coarse-grained, massive sandstone and conglomerate of the Olean. The blocks broken from the ledge are often 15′ or 20′ in height.

The nose of the hill, in the angle formed by the approaching of two streams, is made up of a succession of Pocono cliffs separated by short gentle slopes. The same strata form high and prominent ledges on the side slopes.

The topography of the concealed interval, No. 17, is that of the Catskill, the slope being much greater than that of the Pocono.

North of Bailey run the exposures of the Catskill and Pocono are less frequent and the hill slopes more even and less precipitous.

Near the mouth of Rattlesnake run the Catskill rocks are exposed on the east bank of the First Fork, where they show a decided southeast dip.

Chapter VI.

The Cameron Coal Basin.

The Third Bituminous Coal Basin crosses the Pennsylvania south State line into Fayette county and includes portions of Indiana, Jefferson, Clearfield, Elk, Cameron and Potter counties. The portion of this basin in Cameron has been locally named the Cameron Coal Basin. It includes portions of Shippen, Lumber, Gibson and Portage townships, the greater area, however, being in the former.

The basin measured from the Second to the Third axis varies from 13 to 14 miles in width; but the area occupied by the coal measures, including the Alton Group, is confined to a narrow strip of less than two miles wide on each side of the synclinal axis.

To the northeast of the Sinnemahoning creek the coal measures underlie only the high summits; and gradually are carried above the hill tops by the rise of the basin.

South of the county line the basin expands in width, lying, however, principally to the west of the Bennett's Branch.

The western boundary of the basin is Boon's Mountain whose summits rise over *2000* feet above tide or 200 to 300 feet above the general level of the trough.

The eastern rise of the basin is very gradual and its eastern edge is marked by no such elevated ridge as on the west. The basin is crossed at right angles to its strike by Hunt's run, Sinnemahoning creek, Sterling and Hicks' runs. The first two named and the last cut through the coal and conglomerate measures and expose the Pocono in their beds. Sterling run and its numerous branches penetrate in all directions the coal areas, making them easily accessible.

Hicks' run and its tributaries afford an outlet for the coal of southern Shippen township.

The dips of the basin are very steep for this portion of the State.

The Chemung strata which lie 300 feet above the surface at Emporium pass beneath water level within a mile to the southeast.

The high summit south of Emporium Junction although *2080* above tide or *1070* above the Sinnemahoning, is capped by the Pocono strata, which judging from the elevation of the Catskill rocks, extend some 200 feet below the top. The elevation of the bottom of the restored conglomerate at this point would be in the neighborhood of *2300* feet above tide.

Three miles southeast, at the Cameron Coal Company's incline, the elevation of this same horizon is *1300* feet above tide. This would show an aggregate dip of 1000 feet in 3 miles or an average dip of between 300 and 350 feet per mile.

The dip at the crest of the Boon's Mountain anticlinal is evidently greater and the dip at the center of the basin less than this average, since the southeast dip at the Cameron Coal Company's mine is 3 feet in a hundred or about 150 feet per mile.

The structure of the basin east of the synclinal is exactly the opposite of that to the west; for while in the former the dips decrease as the synclinal is approached, in the latter the gentle dips of the Driftwood axis increase rapidly west of Sterling.

From Driftwood to the summits south of Sterling the elevation of the conglomerate show a dip of 30 feet per mile; but from this point to the center of the basin 4 miles northwest the dip is 150 feet per mile.

In the vicinity of Cameron the dips are even steeper than this. The top of the Catskill which is about 30 feet above the railroad at the station, is 113 feet below the surface in the Cameron well, one half a mile to the northwest. This necessitates a dip of 300 feet per mile.

Dips of about this same rate are shown, by the elevations of the conglomerate, to exist between the well and the Cameron Company's plane half a mile further west. The elevation of the conglomerate at the former point is *1440* feet above tide and at the latter *1300* feet.

This dip evidently decreases greatly in the center of the basin.

The Kinzua-Emporium cross-flexure raises the coal measures north of the Sinnemahoning to a greater height than those to the south; but on account of the lack of developments but few facts as to the dip could be obtained. Less than a mile northeast of the plane there is an old drift upon a coal bed which is evidently the "Star vein." Its elevation is *1495* feet above tide or *40* feet higher than the "Star vein" at the head of the plane.

The dip of the basin to the southwest, along its strike seems to be very gentle, although there are no developments on which to base a correct determination of this dip. The bottom of the conglomerate less than one half a mile east of the synclinal axis where it crosses into Elk county is *1385* feet above tide. The northwest dip could bring this horizon very little if any below 1300 feet above tide.

The Coal Measures of the Basin.

The coal-bearing strata extend from the bottom of the conglomerate up to and include 200± feet of the Lower Productive Coal Measures.

The thickness of these measures together with their description in the different parts of the basin are given in the detailed sections.

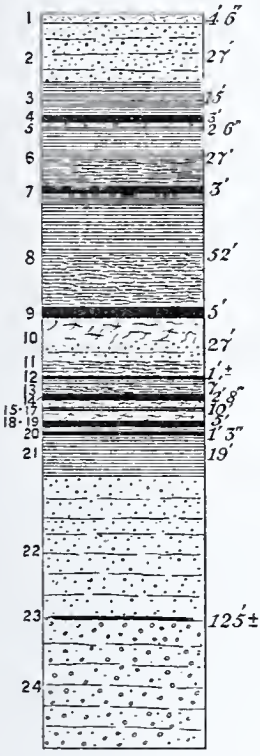
The principal developments in the basin have been made on the lands of the Cameron Coal Co., between the Sinnemahoning and the east fork of Sterling run.

Mr. John Morris superintendent for the above company (1879) who has been prospecting and working in this basin for the past 15 or 20 years, furnished the facts from which the following section was constructed:

1. Drift,	4′	6″
2. Sandstone,	27′	0″
3. Black slate,	15′	0″
4. *Coal*, (*Dagus bed*,)	3′	0″
5. Fire-clay,	2′	6″
6. Gray slate and shale,	27′	0″
7. *Coal* (Sulphur bed,)	3′	0″
8. Gray slate and shale,	52′	0″

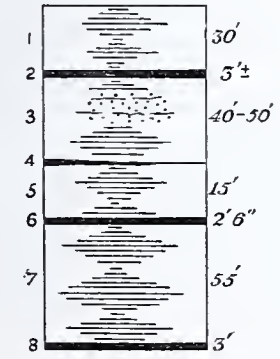
Sections Cameron Coal Basin.

General Section.
page 46

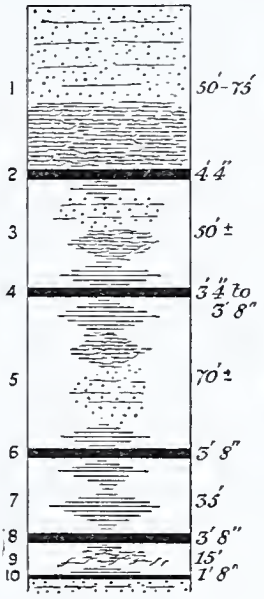


100'=1"

Brooks Section, Sterling Run.
page 58.

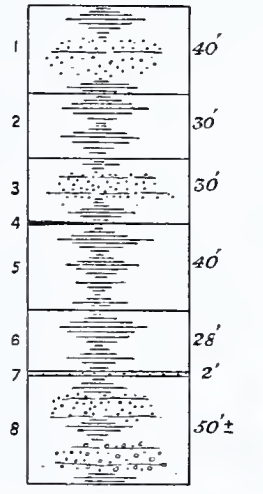


Pardee Tract Section along Sterling Run. page 56.



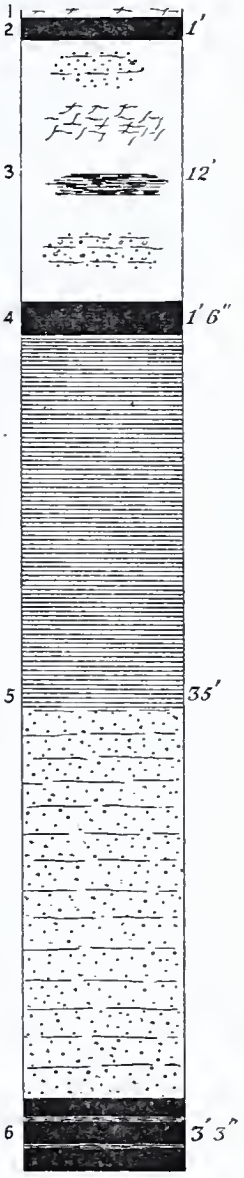
100'=1"

Canoe Run Section.
page 55.



100'=1"

Drum House Section, C. C. Co.
page 53.



10'=1"

9. *Coal* (5 foot bed,) *Clermont bed*,	5′	0″
10. Fire-clay,	27′	0″
11. Soft sandstone and shale,		
12. *Coal*, (rider to "Star vein,")	1′	0″±
13. Black and gray slate and shale,	7′	0″
14. *Coal*, ("Star vein,")	2′	8″
15. Fire clay,	3′	6″
16. Slate,	1′	6″
17. Fire-clay,	5′	0″
18. *Coal*, (Bogus cannel,)	5′	0″
19. Slate,		
20. *Coal*,	1′	3″
21. Slate,	19′	0″
22. KINZUA CREEK SANDSTONE,	125′	0″±
23. *Marshburg coal*,		
24. OLEAN CONGLOMERATE,		

Strata 1 to 5 inclusive were obtained in a hole drilled to a depth of 46.5 feet, at a point 2,000 feet S. 70° W. of the mouth of the present opening of the Mount Hope mine.

The 27 feet of sandstone, (stratum No. 2) has never been encountered in any other locality; but elsewhere the interval is composed of soft shale.

Where the sandstone was found, the underlying slate and coal were of a much more tender character, and the coal cleaner and of purer quality.

Strata 14 to 20 and possibly 21 represent the *Alton group* with its included coal-beds.

Strata 11, 12 and 13 compose the JOHNSON RUN SANDSTONE, the top member of the Conglomerate measures No. XII.

The coal in stratum No. 4 is the same as the *Dagus coal* of McKean and Elk counties and has been identified by Mr. Ashburner as the *Kittanning lower coal.*

This coal is the most important bed opened in this portion of the State along the line of the P. & E. RR. It is mined extensively in Elk county, at the Tannerdale and St. Mary's mines of the St. Mary's Coal Co. and the Cascade mine of Kaul and Hall in the vicinity of St. Mary's, and at the extensive workings of the Northwestern Mining and Exchange Co. near Centerville.

The present workings of Mount Hope colliery of the Cameron Coal Company are upon this bed; and are situated at an

elevation of *1590* feet above tide or *485′*± above the Sinnemahoning about 2 miles a little north of west of the old original Mount Hope opening.

The average section of the bed in the mine, October, 1879, was:

Black slate,	—
Coal,	3′
Fire-clay,	—

The black slate roof is very good.

The analysis of this coal made by Mr. A. S. McCreath of the survey together with the description of the sample sent him is given below:

Water,	.990
Volatile matter,	34.395
Fixed carbon,	60.195
Sulphur,	.865
Ash,	3.555
	100.000
Color of ash,	cream.
Coke, per cent.,	64.615
Fuel ratio,	1.175

"Luster dull-black; generally very firm; somewhat coated with silt; shows only a few thin scales of pyrites."

The character of this coal as a gas coal is shown in the testimonials received by the company, from the Philadelphia gas works, the Metropolitan and Manhattan companies in New York city, the Citizen's Gas Light Company of Brooklyn and others.

These tests show that the average yield of gas was between 10,000 and 11,000 cubic feet of 16 candles illuminating power, per ton of 2240 lbs.

The Manhattan company reported that "when the yield was restricted to 9,500 cubic feet per ton the illuminating power was equal to 19.07 standard candles."

The yield of coke per ton was 42 bushels.

The following general description of the mine was obtained by Mr. Ashburner in the latter part of 1878:

Course of main entry,	S. 70°, W.
" " cross headings,	N. 60°, W.
" " face of slips,	N. 20°, E.
" " end "	S. 60°, W.

The main entry was 1400 feet long. Four cross entries: 1st, 1200 feet long 400 feet from mine mouth; 2d, 1250 feet long 700 feet from month; 3rd, 1300 feet long 1000 feet from mouth of mine; and 4th, 200 feet long, 1300 feet from mine mouth. All the cross entries were connected by breast-works except 3rd and 4th and 2nd and 3rd. There are 40 connecting breast-works between 1st and 2nd entries.

The air courses were 6′ wide and 16′ to the right of the main entry, running to the head of the entry. The average dip of the coal in the mine is 3 feet to 100 feet S. 20° E.

The average output of the mine in October, 1879, was 150 to 175 tons per day.

"The present opening has been worked about 3 years."

The Cameron Coal Company worked their property from 1865 to 1875. Many of the facts connected with the history of the Cameron coal basin have been published in various forms sometimes correctly, more frequently incorrectly. The following statements were published several years ago in the Cameron Independent and as it is the most reliable article it is republished here as a matter of record:

"The coal area of Cameron county lies geologically in the third great basin of the bituminous coal field, between 60 and 70 miles back from the mouth of the gorge of the West Branch of the Susquehanna river at Lock Haven. Its coal beds overlay the great conglomerate No. XII and occupy the top of the ridges and spread back through the uplands which are everywhere 600 to 700 feet above the track of the Philadelphia and Erie Railroad, running as far as Emporium parallel with the Driftwood branch of the Sinnemahoning river, which latter divides the beds in an eastern and western coal field. Both of these have been sufficiently explored, but only the western actually worked.

"According to Professor Lesley's private survey and report the principal body of coal in the eastern field lies south from the Huff farm, on the ridge between the valley of the Driftwood and that of Hunt's run, and on the table land around the head of the different branches of Hunt's run, towards the northeast; mostly on the properties of the Cameron Coal Company, John Brooks and the Hunt's Run Lumber

Company. On the ridge referred to, five different veins have been proven, and three opened by the Cameron Coal Company. The western field extends from Sterling run and its branches in a northwesterly direction on the western ridges of the Driftwood Branch nearly opposite Emporium, and has its axis near the junction of the two Canoe runs. The lands which lie nearly along the center of this coal basin are owned by the Canoe run estate, A. Pardee, A. C. Noyes, P. W. Whiting and the Cameron Coal Company. Drifts have been opened on all these lands and the existence of veins established.

"Coal has been mined for home use and is worked to-day at Sterling Run, thence further north, by George Chapman and Stewart on their farms, adjoining the property of the Cameron Coal Company. To this company belongs the credit of first opening, working and shipping coal on an extensive scale. They worked on their own property, the Mount Hope vein No. 1, 36 inches, Mount Hope vein No. 2, or Laurel vein, 30 inches, and the Star vein 40 inches, from the year 1865 to 1875, shipping as high as 45,000 tons of coal per year. In the summer of 1874 the company's works were connected by tramway with the lands of the Canoe Run estate, passing over the warrants of the old "Shippen Coal Company" (Simon Cameron, president) and coal mined on both of these properties. In the fall of 1875 Jacob Elias, one of the owners of the Canoe Run estate and the tramway connecting it with the works of the Cameron Coal Company, leased the works; commenced mining at Simpson's ridge, and has continued ever since, shipping from 30,000 to 40,000 tons of first class coal annually. Of the three veins opened, the Mount Hope No. 1, Mount Hope 2 and a lower vein of coal, only the first is worked at present to any extent, and some 75 miners and 40 drivers and outside men, or in all 125 men, employed."

The interval between the *Dagus coal* and the *Clermont* usually contains the *Clermont* (*Ferriferous*) limestone, but no such stratum has been found in this portion of the basin.

The Hon. John Brooks of Sinnemahoning reports, as stated before that pieces of a limestone resembling the *Clermont*

were found on Sterling run, but that the position of the bed could not be determined.

The Ferriferous limestone is generally accompanied by an underlying coal bed which has been called the *Scrubgrass* coal. It may be possible that the unworkable coal which in several localities in this county, is found 30 to 40 feet below the *Dagus* bed, is the representative of the *Scrubgrass* coal.

Eighty feet below the *Dagus* bed is the "five-foot" bed, the representative of the *Clermont* or *Clarion* coal. The interval between this bed and the *Dagus* is composed of gray slate and shale similar in character to that occupying the same geological horizon generally throughout Elk county.

This bed has been opened in several places upon and in the vicinity of the Cameron Coal Co's lands, and although it varies somewhat in thickness, yet it is generally a large and workable seam.

About ½ mile southwest of the Mount Hope mine this bed has been opened and found to be 4 feet thick, without bone or separating slate.

The bed at this point, however, contains a great deal of sulphur, which diminishes as it gets further under the hill.

There are some thin bands of bony coal throughout the bed, and the sulphur weathers out along their edges. The coal has a conchoidal fracture, and resembles in every way the structure and character of the coal mined from the same horizon at Clermont, McKean county.

This coal was opened at the Patterson opening on Canoe run, 42 feet above the "Star vein" in the Sherman opening and 86 feet below the *Dagus* bed.

Prof. Lesley in a report to the Shippen Coal Co. in 1864, says the bed at this point is 3 feet 4 inches thick.

It was also proved at the Noyes opening in the same vicinity and reported to be of the same thickness.

The analysis of a specimen of this bed made by Mr. A. S. McCreath is :

"Water,	.920
Volatile matter,	32.220
Fixed carbon,	53.904

Sulphur,	3.481
Ash,	9.475
	100.000
Color of ash,	pinkish gray.
Coke per cent.,	66.860
Fuel ratio,	1:1.67

"Luster generally bright, shining; rather firm; shows numerous thin partings or knife edges of pyrites, and considerable mineral charcoal."

The "Star vein," stratum No. 14, is one of the Alton coals and occurs some 35 or 40 feet below the *Clermont* coal, underlying the JOHNSON RUN SANDSTONE, the top member of XII.

In the Sherman opening on Canoe run Prof. Lesley reported this coal to be 3 feet thick.

It is generally a two-bench coal separated by a clay band.

This coal as well as the others of the Alton group are in this part of the State, very ashy, generally sulphurous, and much inferior to the overlying beds.

Strata Nos. 18 and 20 are respectively the *middle* and *lower Alton coals*.

Between the "Star vein" and the *Clermont* bed Prof. Lesley reports two thin beds of coal 1′ and 18″ inches in thickness, too thin however to be of any value.

About ½ mile from the Drum house Mr. Morris reported the following section:

1. Soapstone,				—
2. *Coal*,			1′	0″
3. Sandstone, soapstone, fire-clay, coal slate and "conglomerate matter,"			12′	0″
4. *Coal*,			1′	6″
5. Gray slate and sandstone, (This interval is sometimes all sandstone,)			35′	0″
6. *Coal*,	0′	10″		
Bone,	0′	3″		
Coal,	1′	0″	3′	3″
Bone,	0′	2″		
Coal,	1′	0″		

In going west from this point to the mouth of the mine, the 12 feet of conglomerate matter disappears, and in a distance of 1½ miles, the one foot and eighteen inch beds (Nos. 2 and 4 of section) unite and form the "five-foot" or *Clermont* bed. The cover here is soapstone.

No. 6, the "Star vein' or *Alton upper coal*, here consists of 3 benches separated by streaks of bone.

North of Cameron on the hill between the Sinnemahoning and Plank road branch of Hunt's run, some of the coal beds have been proved but no mining operations have been carried on.

The *Kinzua-Emporium* anticlinal has elevated the measures somewhat, and the summits are lower than on the west side of the Sinnemahoning, so that the thickness and extent of the coal measures are less than in the area just described.

About $\frac{3}{4}$ of a mile northeast of the head of the Cameron Coal Co's incline and *530* feet above Cameron station an old drift was visited, which probably was on the Star vein.

The summit immediately above this drift is *90* feet higher, and probably contains the five-foot or *Clermont* bed. The hillside above the drift contains loose pieces of a flaggy coarse-grained sandstone, while below pieces of sandstone and conglomerate occur.

North of this drift prospecting shafts have been sunk on a bench marked by a series of springs. The elevation of this terrace decreases gently towards the northwest as it approaches the synclinal axis: 120 feet below the terrace and at an elevation of *1355* feet above tide (*400* feet above the valley of the Sinnemahoning) the massive sandstones of *XII* outcrop in a ledge of pink and gray compact sandstone with angular pebbles, blocks of which cover the hillside below.

Between the coal bench and this ledge the loose pieces of sandstone show that the slope is underlaid by the conglomerate measures.

The above ledge is undoubtedly the outcrop of the Olean Conglomerate and probably marks its base. The distance vertically between this ledge and the coal-bed above it would make it appear that the coal is one of the *Alton* beds and probably the "Star vein."

One and a half miles northwest of the mouth of Canoe run about on the synclinal axis the following partial section was constructed:

Summit *1580* feet above tide.

1. Partially concealed; some loose pieces of shaly sandstone, . 40′
   Bench, covered with loose thin slaty sandstone, ... —
2. Concealed, ... 30′
3. Bench partly concealed; loose fine-grained, gritty sandstone full of carbonaceous matter and plant impressions, near top, ... 30′
4. Coal bench, swampy, old drift on it, ... —
5. Concealed to flat, ... 40′
6. Concealed, ... 28′
7. Coarse grained slaty sandstone, ... 2′
8. Interval, loose blocks of conglomerate and massive sandstode, iron springs at bottom, ... 50′±

Strata Nos. 6, 7, 8 and part of 5 seem to represent the KINZUA-CREEK SANDSTONE and the OLEAN CONGLOMERATE No. 4 is probably one of the Alton coals, possibly the "Star vein."

No. 3 may be the JOHNSON RUN SANDSTONE.

Northwest from this point the measures rise rapidly towards the *Emporium Dome.*

In this ridge between the Sinnemahoning and Hunt's run three coals respectively 24, 40 and 30 inches in thickness and *529*, *575* and *660* feet above the railroad grade, are reported to have been opened by the Cameron Coal Company.

The openings have fallen in and the coal could not be seen.

The beds are probably the "Star" or *Alton upper*, the "Five-foot" or Clermont, and the "Mount Hope" or *Dagus* bed, the distances apart corresponding to the intervals between these beds where measured at Mount Hope.

Sterling Run.

The greatest area of the coal measures in the county lie around the branches of Sterling run. Numerous openings have been made in various seams, and some coal has been mined for local use, but no extensive operations have as yet been begun. Hon. John Brooks of Sinnemahoning has proved the seams upon the Pardee lands formerly owned by him.

The following section was constructed by Mr. Ashburner in warrant 5869, Pardee tract, on Mill branch of Sterling run:

1. Sandstone and shale,		50 to 75′	0″
2. *Coal*, reported,		4′	4″
3. Interval, (sandstone and shale,)		50′	0″±
4. *Coal, Dagus* (Mount Hope) bed,		3′ 4″ to 3′	8″
5. Interval, (shale and sandstone,)		70′	0″±
6. *Coal, Clermont* ("five foot") bed, reported,		3′	8″
7. Interval,		35′	0″
8. *Coal* ("Star vein,") reported,	*Alton group.*	3	8″
9. Interval, (shale and fire-clay,)		15′	0″
10. *Coal*,		1′	8″
KINZUA CREEK SANDSTONE,		—	
Total,		262′	0″

The openings on the beds in the above sections were made in 1870, and are now so closed up, by falls of the surface, that the coal can not be seen. Mr. Brooks, who saw the beds when opened, is the authority for the description of their character and thickness.

The top coal of the section (stratum No. 2,) was proved by a shaft 14 to 16 feet deep, $\frac{2}{4}$ of a mile northwest of the portable mill, and found to measure 44 inches in thickness.

This bed is probably the same as the bed which occurs 55 feet above the *Dagus bed* at St. Mary's. The cover over the coal ranges from 50 to 75 feet in thickness in the center of the basin, to which its limited area is confined.

The *Dagus bed* was opened by two drifts 250 feet apart $\frac{1}{2}$ mile northwest of the mill.

The opening further to the west is from 5 to 10 feet lower than the other, showing the presence of a local roll.

The sections of the bed at the first of these openings is:

Coal,	3′	4″
Clay,		—

At the second or more easterly drift it is:

Coal,	3′	8′
Fire-clay,		—

Mr. Brooks reports the coal to be in one solid bench, showing no partings of either sulphur or bone. It differs from the underlying *Clermont* coal in having a red ash, in containing less gas, and in the character of its fracture.

Midway between these openings and the mill there is a drift, called the *Greek opening* on the *Clermont bed.* The section as reported is:

Coal,	0′ 6″
Sulphur,	0′ 1″
Coal,	3′ 1″

This bed shows a slight dip to the northwest.

The coal contains a great deal of gas and "runs" on burning, but contains no clinker. The ash is white. Mr. Brooks considers it the best coal for stove and grate use opened on the Pardee tract. At this point two lower beds were opened, but no information in regard to them could be obtained.

The two *Alton beds* have been opened, on the first fork of Sterling run in the northern part of this same warrant (5869).

The upper coal was proved in an open cut in the hillside by Mr. Brooks, and is reported to measure as follows:

Black slate,	—
Coal,	3′ 8″
Fire-clay,	—

The coal contains considerable sulphur, is compact, large pieces three feet square having been taken out, and burns with a great deal of clinker. Several hundred tons have been mined at this opening for local use.

The bed, as marked in the section, is undoubtedly the top coal of the *Alton group* and the equivalent of the "*Star vein*" at Mount Hope; 120 feet N. 80° E. of the above opening (Brooks' coal opening No. 1,) is the No. 2 opening on the bed 15 feet beneath the "*Star vein.*"

The coal was not seen, the opening having been filled up, but it is said to have measured:

Slate and fire-clay,	—
Coal,	1′ 8″
Hard fire-clay,	—

Southeast of Brooks' opening No. 1 is what is called the Trump coal opening No. 1. Mr. Benj. Smith Lyman, in his "Notes of Reconnaissance of Brooks' Tract," made in November, 1865, reports that he saw 2′ 8″ of coal in the drain. Mr. Trump said at that time, that the full thickness was 3′ 6″. Mr. Lyman says "the coal is hard and firm even here at the crop," and "that it had a streak of sulphur in it near the bottom, that grew thinner going in and was easily separated."

The roof consists of a firm black slate, and the bottom of a tough hard fire-clay at least 18″ in thickness.

The bed was considered the same as in Brooks' opening No. 1, in which case it would be the *Alton Upper coal.* The coal was mined in an open cut and was followed 12 feet under cover by a drift.

Less than ½ mile a little east of south of No. 1 and on the east bank of the east fork of the mill branch of Sterling run, near the south edge of warrant 5869, is the Trump opening No. 2.

Mr. Lyman reports the coal opened by a "monkey drift" some 25 feet long.

The coal was 27 inches thick, rotten and very soft, overlaid by rotten shales.

This bed by Mr. Lyman's levels is lower than the No. 1 opening.

Twenty yards east of No. 2, and above the No. 3 opening, only 19 inches of coal has been opened.

A short distance above opening No. 3, and 100 yards northeast of it, an outcrop of a coal seam was found, but was never developed. Mr. Brooks, Mr. Lyman says, considered this to be the same bed as the *Mount Hope bed* of the Cameron Coal Company.

On the Cochrane road branch of Sterling run, warrant 5979, the coals shown in the following section were opened:

1.	Concealed,	30′
2.	*Coal,*	3′±
3.	Partially concealed, coarse loose pieces of sandstone,	40′ to 50′
4.	*Coal,*	—
5.	Concealed,	15′
6.	*Coal,*	2½′
7.	Concealed,	55′
8.	*Coal,*	3′
	Total,	158′ 6″

The above thicknesses were reported by Mr. Brooks, since it was impossible to see the beds; the openings having fallen in. Mr. Ashburner identifies No. 2 as the *Clermont bed;* 4 and 6 as the two *Alton coals,* 4 being the "*Star vein;*" and 8 as the *Marshburg bed,* between the KINZUA CREEK SANDSTONE and the OLEAN CONGLOMERATE.

In the western part of warrant 5947 are the Felt and Durfee openings. These were revisited in 1865 by Mr. Benj. Smith Lyman, who reported the coal beds opened at them as 31 and 30 inches thick respectively, on the outcrops.

The Durfee opening is about 500 feet southeast of the Felt opening and is higher. In the southern part of warrant 5979, and on the headwaters of Bell Camp branch, Mr. Lyman saw two beds, the lower one measuring 3′ 8″ in thickness and the upper one 2′ 2″ thick. Mr. Brooks considered the lower coal the same as the "*Star vein.*"

Tannery Hill.

On the hill 1 mile southeast of Sherwood's tannery at the forks of Sterling run, a coal bed, considered by Mr. Ashburner the *Marshburg coal*, was opened in 1873, and is reported to be 30 inches thick. The bed is *475* feet above the tannery or 1480 feet above tide.

Sixty-five feet below the coal is a terrace which marks the bottom of the OLEAN CONGLOMERATE. Fifty-five feet above the same bed the steep slope suddenly flattens, and here probably is the top of the KINZUA CREEK SANDSTONE.

Coarse-grained hard and rather massive sandstone appears on this slope; 100 feet below the bottom of the conglomerate and 80 feet below the top of the steep slope, below the edge of the terrace, is a thin band of red shale which may possibly be a portion of No. XI.

On the Oak Hill farm, one thousand feet southwest of the above opening, the same coal has been opened at an elevation of *1475* feet above tide or *470* feet above the tannery.

The coal is reported to measure 30 inches. Sandstone resembling very closely the KINZUA CREEK rock overlies the bed.

General Section in Cameron County.

The rocks exposed in Cameron county belong to the Carboniferous and Devonian ages; and are contained in the following groups, arranged in the reverse order of their deposition·

Lower Productive Coal Measures, and Pottsville (Seral) conglomerate,	No. XII,	400′+
Mauch Chunk (Umbral) Red shale,	No. XI,	50′
Pocono (Vespertine) sandstone,	No. X,	700′
Catskill (Ponent) group,	No. IX,	500
Chemung (Vergent),	No. VIII,	350′
Total,		2,000′

The total thickness of these rocks above water-level, adding together the maximum of each formation, is about 2000 feet; and if to this we add the Chemung strata pierced by the Bond Farm well, we have a studied rock column 3400 feet in height. In no one place can the above total of 2000 feet be measured, since the greatest difference of elevation is but 1500 feet, and since the strata are nowhere inclined at a steep angle, but are nearly horizontal. The areas covered by the outcrops of the above groups are shown on the geological map accompanying this report. (Plate III, Atlas RR.)

REPORT OF THE PROGRESS

OF THE

SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA

IN

ELK COUNTY,

By Charles A. Ashburner.

DETAILED GEOLOGY OF THE SEVERAL TOWNSHIPS.

Chapter VII.

Jones Township.

Jones lies east of Highland, south of Wetmore and Sergeant in McKean county, west of a small part of the latter township, and of Shippen in Cameron county, and north of Benzinger and Ridgway.

The greater part lies in the Mississippi basin. The Appalachian divide passes through the extreme eastern part of the township, and cuts off a comparatively small area, which lies in the Atlantic basin. This latter portion is drained by the North fork of West creek, by Clear creek, and the head branch of Driftwood creek. The larger portion of the township lying in the Mississippi basin is drained entirely by the brances of the Clarion, which flow in almost

every possible direction, although in a general way south, south-east, or south-west. Many of the streams at their junction make a letter V with the point toward the south. This peculiarity in the flow of the streams renders the topography of the township very intricate, and sometimes perplexing, even to the best woodsman.

Among the principal streams in the township may be mentioned: the East Clarion, which flows southwest, having for its principal branches Crooked creek, Middle creek, Straight creek, Instantur creek, Seven Mile creek, Burlingame run, Swamp run, and Johnson run; the first three emptying into the stream on its left bank, and the last three on its right bank.

The main stream of the West Clarion, which rises south of Howard hill in McKean county, flows nearly due south past Wilcox to the south line of the township, about midway between Bridgetown and Wilmarth. The principal branches of the West Clarion emptying into it from the left are, first, one immediately below Bridgetown, whose name I have been unable to learn, (if it ever has been designated by a special name,) Oil creek, and Rocky run. Coming into the stream from the right hand are, first on the north, Wilson run, Wolf run, and Clearwater run. The latter two, however, unite about one mile above the point where their waters join the Clarion.

The south-western corner of the township is drained by Silver creek, which flows into the Clarion about a quarter of a mile above Johnsonburg; the Little Mill creek, which flows into it below Whistletown; and the Big Mill creek, which flows into the Clarion River, proper, about three miles below Ridgway.

The topography of the township is extremely varied. Its main features have been determined by the geological structure, the highest portions of its surface being located over the anticlinal axes, which are the *Fifth* in the north-western part, and the *Fourth* or *Norwich* and the *Kinzua-Emporium cross-anticlinal* both in the eastern part. The lowest elevations are, in general, through the central part of the township along the East Clarion, whose general direction

has been determined by the axis of the *Johnson Run or Fifth basin*, the axis and stream being nearly parallel one to the other, the latter being about two miles east of the former. The best farming region in the township is probably located in the *Johnson Run basin* east of Wilcox, and between Wilcox and Williamsville. The relation between the stratigraphy and the topography in this township is a more apparent one than probably anywhere else in the county.

The erroneous conclusions which have been maintained by local geologists, in the past, as to the stratigraphical connection of the coal measures here with those in portions of the State to the south-west, would appear to be largely due to an unfamiliarity with the local succession of the coal strata in individual sections, and the nature of the topography which the more prominent and persistent strata has determined. Although, to one whose attention has been directed to it for a number of years, the characteristic relief in the profiles of the hills, produced by special rocks in the series, is very apparent, some of the many geologists who have explored the north-western part of the State have been honestly deceived, for want of a sufficiently extended experience throughout the bituminous coal areas.

The author first visited this region in the early summer of 1876 in company with General Kane and some of his associates of the old Elk Land and Improvement Company. The geological views held by *some* of these gentlemen, and particularly by General Kane, were the inevitable conclusions of those who had given a great deal of time to the exploration, mapping, and study of this special field, without, however, familiarizing themselves with the geological features and structure of the coal measures in adjoining portions of the bituminous region.

During the summer of 1876 and 1877, when repeated visits were made to the coal basins of Jones township, in the headwaters of Johnson run and Silver creek especially, the generally accepted solution of the geological structure seemed to be substantiated by the facts which up to that time had been collected. But after a more extensive study

of the geology throughout the four counties of McKean, Cameron, Elk, and Forest, and the mapping of the topography of McKean, but little difficulty was experienced in correctly connecting the geological structure of the coal measures throughout the district, and then it was that the study of the topographical features in Jones township became valuable in arriving at conclusions very different from those at first accepted. These conclusions, it is believed, will be found to agree with future mining developments, and with the results of more careful and detailed geological surveys than it was the privilege of the author to make.

The greatest height in the township, that was measured, is Jarret's summit, in the eastern part, the elevation of which is 2245 feet.

The lowest point is where the Clarion River crosses the southern line into Ridgway township, about midway between Bridgetown and Wilmarth, at an elevation of about 1460 feet above tide. The general elevation of the township is high, although not as great as that of Highland.

The structural geology of the township is more varied than that of any other township in Elk. The central and greater part of its area is confined within the limits of the *Fifth Bituminous basin*, which is locally named in Elk county the *Johnson Run coal basin*, from the fact that the coal beds along Johnson run, in this township, have, in the past, been better and more favorably known than those anywhere else in this basin, within the county. The general position of the axis of this basin crosses the Clarion River about midway, in an air line, between Bear creek and Irwin's mills. From this point its general direction is nearly due north-east, passing through the Schultz farm at Montmorency, crossing the P. & E. R. R. about half a mile south of Bridgetown, and passing north-west near T. Weitoff's house. Beyond this point it was not possible to trace the axis of the basin, on account of a flattening of the dips, caused by a higher elevation of the strata at this point, due to the *Kinzua-Emporium cross anticlinal axis.*

This basin is the same as that in which the Buffalo Coal Company's mines at Clermont are located. The axis of the

basin passes very nearly through the railroad station at Clermont south-west to Williamsville, where all traces of the synclinal were lost, due to the same cause as that referred to in tracing the axis of the *Johnson Run basin* north-east. This apparent break or offset in the axis of the *Fifth Bituminous basin*, near the McKean and Elk line, in the vicinity of Williamsville, has led many of the local geologists to conclude that there were two distinct basins.

Few outcrops are to be found in the vicinity of Williamsville, and the differences which exist in those which were discovered, as well as the differences in the general topographical features from those which are observed in the vicinity of Clermont, and south-west along Burlingame, Swamp, and Johnson runs, tend to confuse the closest observer, and are without doubt the cause of the impression which has prevailed that little similarity, either in structure or stratigraphy, exists between the basin at Clermont and that in the vicinity of the runs named.

The extreme eastern portion of the township lies in the *Fourth Bituminous basin.* The axis of the *Norwich basin*, which is boldly defined through the center of Norwich township, McKean county, and the southern part of Liberty township in the same county, is hardly distinguishable in the north-eastern corner of Jones township. This is due to the fact that the basin rises and becomes flatter toward the south-west as it approaches the *Kinzua-Emporium cross anticlinal axis.*

The north-eastern terminus of the *St. Mary's basin*, which lies within the same general synclinal (Fourth *Bituminous*) as the *Norwich basin*, is to be found in the northern part of Benzinger township. The position of the axis is more correctly represented on Plate II than on Plate I. The great elevation of the strata along the north fork of West creek in the vicinity of the *Kinzua-Emporium cross-anticlinal axis*, by which the CATSKILL ROCKS are brought to the surface, and which occurs very nearly along the central line of the *Fourth Bituminous basin* at this point, has obliterated entirely all evidence of the existence of the synclinal axis here. Economically, this fact is very important

as bearing upon the existence of workable coal beds under any considerable area in the extreme eastern part of Jones township. A few scattered outcrops of coal beds were located here; but, from the fact that no openings have been made where the face of the coal could be seen, it was impossible to determine their stratigraphical relationship. Judging, however, from the few disconnected facts which could be obtained in this thickly-wooded region, it is to be questioned whether any coal beds exist here, higher than the *Clarion*. In fact the existence of this latter bed is to be questioned. Before anything can be certainly asserted, however, as to the actual value of these lands for coal mining purposes, extensive prospecting work will be required.

There are several coal openings in the center of the *Norwich basin* in McKean county just north of the McKean-Cameron line, about six miles north-east of the south-western end of the *Norwich axis*, as represented on the map of Elk county (Plate II) At this point the highest bed opened was the *Clermont bed*, and since all the facts point to the conclusion that the basin rises toward the south-west from this point, the chances for finding this coal bed in north-eastern Jones would appear not so good as in Norwich township, McKean county. Reference is made to the openings in the latter locality in the McKean report,* as follows:

"Several coal openings have been made near the head-waters of Indian run in the southern part of the township. The *Clermont coal* has been opened at an elevation of 2080′, and is reported as being 4′ thick. A second opening was made further to the north and 20′ lower; this bed was also reported 4′ thick, and is possibly the representative of the *Alton Upper coal*. The top of the ridge near the openings is 2187′ high, and is immediately underlaid by yellow flaggy sandstone."

"About one and a half miles north of this opening a bed 4′ thick (?) was drifted on at the Dennison opening. The elevation of the coal is 2015′. A conglomerate containing

* Report R, page 118.

small pebbles was found below the opening, and is the representative of the OLEAN, so that the Dennison coal is the *Marshburg Upper bed.*"

The anticlinal axes in Jones township are more boldly marked than the synclinal axes. Reference has already been made to this in the chapter on the structural geology of the district.

The main characteristic of the *Kinzua-Emporium anticlinal axis*, that of being composed of a series of domes, along the line indicated on the map, is clearly defined in the eastern part of this township. In the vicinity of Jarret's summit and Williamsville the axis is prominently marked by the dips of the outcropping rocks. Along Straight creek, however, its presence is not so distinctly defined.

The outcrop of the coal measures between Instantur creek and Straight creek, north-east of the Kinzua axis, has not been correctly represented on the county map. A special map of this locality has been prepared by Mr. Robert P. Field, Mining Engineer, and is published as Plate IX in the atlas; further reference is made to the differences existing between these two maps on page 82.

The *Norwich anticlinal* crosses the McKean-Elk line in the vicinity of the main branch of Straight creek. After leaving the county line, however, the anticline seems to flatten and to sink slightly to the south-west as it approaches the line of the *Kinzua axis*, as represented on the map, (Plate I.) The continuation of this axis to the south-west, designated "*Anticlinal (Fourth) axis*" on the Elk map, is distinctly marked. The dip between the axis and the outcrop of the CATSKILL rocks along North fork creek is uncertain, as far as the facts obtained determine it. The north-west dip, however, toward Clarion creek is distinctly marked by the outcrops to be found along the creeks flowing into the Clarion in the general direction of the dip.

The *Fifth anticlinal axis* cuts across the north-western corner of the township, and the dips on either side of it, as far as could be determined, do not exceed a greater average rate than about 40 feet to the mile.

The aggregate thickness of the rocks outcropping in the

Fig. 1. p. 69.
Johnson Run Basin in vicinity Bucktail Mines.

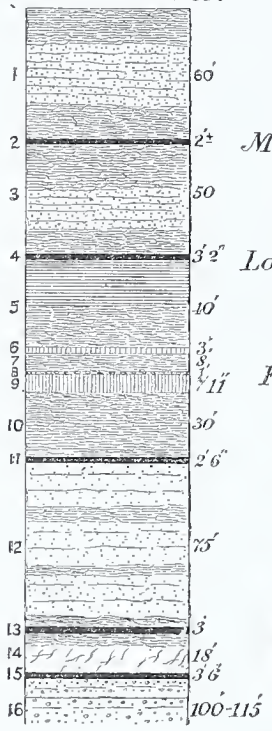


Fig. 2. p. 70.
"Roberts Lot" by Joseph Lesley.

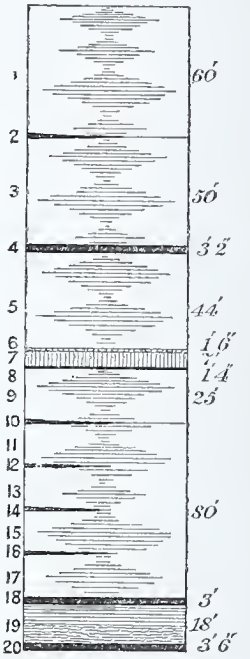


Fig. 5. p. 81.
"Shaft" Bed, Johnson's Opening.

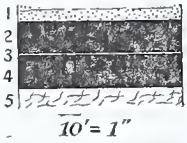


Fig. 4. p. 79.
Alton Group, "Roberts Lot" by Joseph Lesley.

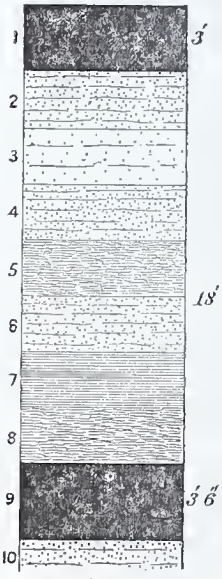


Fig 5. p. 73.
Ferriferous Limestone Kane's Quarry.

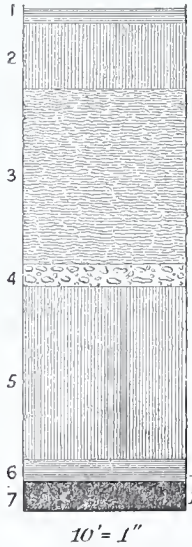


Fig. 3 shows the maximum development of the Ferriferous Limestone in Northwestern Pennsylvania.

Lower part of Fig. 2, enlarged.

township is 1015 feet, the highest being found immediately underlying the summit of Pistner hill, and the lowest along the North fork of West creek. These strata may be grouped as follows:

Coal measures, (including the conglomerate No. XII,)	420′
Mauch Chunk No. XI,	45′
Pocono No. X,	500′
Red Catskill No. IX,	50′+
Total,	1015′

Nearly 1400 feet of Devonian strata below the base of the above section are pierced by the Bear Creek well.

The coal measures in the *Fifth basin* in Jones are characterized by greater variations, both as to thickness and character, than has been found to maintain anywhere else in the district. This fact has confused very materially the local geologists, and the opinions held as to the stratigraphy have been various. The two principal coal areas are what have been variously called the *Johnson Run, Kane's, Clay's, or the McKean-Elk Land and Improvement Company's basin*, lying between the branches of East Clarion creek and West Clarion creek; and the *Silver Creek, Bear Creek, or Schultz basin*, lying south-west of the West Clarion and between Bridgetown and Highland settlements. The general section of the coal measures in the former basin is as follows (Fig. 1, page 68):

1.	Shales and shaly sandstone,	60′	
2.	*Middle Kittanning coal bed,*	2′±	
3.	Shales and shaly sandstone,	50′	
4.	*Lower Kittanning coal bed,*	3′	2″
5.	Slate and shale,	40	
6.	*Ferriferous limestone, (Top bench.)*	3′	
7.	Shale,	8′	
8.	Iron ore,	1′	
9.	*Ferriferous limestone, (Bottom bench,)*	7′	11″
10.	Shales,	30′	
11.	*Clarion coal bed,*	2′	6″
12.	Sandstone, massive, with occasional shale bands,	75′	
13.	*Coal,*	3′	
14.	Sandstone, shales and fire-clay } *Alton coal group,*	18′	
15.	*Coal,*	3′	6″
16.	Sandstone and conglomerate, coal horizon near center,	100′-115′	
	Total,	407′	1″+

The local names which have been assigned to the coal beds in this section have been numerous. One bed has not

only been known by a number of names, but different names, which have been currently held to indicate as many different beds, have frequently been applied to openings in different localities, which have ultimately been found to be on the outcrop of the same bed. In some cases, a diversity of opinion, between local authorities, has led to the greatest confusion in the identification of beds opened at different localities. For this reason it is believed it would be impossible to harmonize the names, which have been given to the different coal beds named, on the ground and in the columnar sections, contained in a number of local reports which have been published. The report which contains the most correct conclusions in regard to this special locality is the "Geological Report on the Roberts Lot, Elk county, Pennsylvania," made by Mr. Joseph Lesley, topographical geologist, in January, 1865. The principal portion of the section, reported by Mr. Lesley for the Johnson Run tract, is almost identical with the same section constructed by the Survey, already given. This section is given below as copied from Mr. Lesley's report.

Top of Pistner hill—north end of "Robert's Lot" (Fig. 2, page 68).

1.	Interval,	60′
2.	*Coal*, thickness not determined,	—
3.	Interval,	50′
4.	*Coal*, "*Gas vein*,"	3′ 2″
5.	Interval,	44′
6.	Iron ore,	1′ 6″
7.	Limestone,	7′
8.	*Coal*, found at lime kiln,	1′ 4″
9.	Interval,	25′
10.	*Coal*, thickness not known,	—
11.	Interval,	80′
12.	*Coal*, "*Lime coal*," place or thickness not accurately determined,	
13.	Interval,	
14.	*Coal*, thin seam,	
15.	Interval,	
16.	*Coal*, thin seam,	
17.	Interval,	
18.	*Coal*, "*Lower Cannel*,"	3′
19.	S. S. and slates and shales,	18′
20.	*Coal*, "*Shaft vein*,"	3 6″
	Total,	296′ 6″

To this section was appended a section reported by Mr. A. F. Dalsen, which does not represent the structure anywhere in the county, below what Mr. Lesley calls the "*Shaft Vein*," which is the representative of the *Alton Lower bed*. In the first section given, which is identical with that on the sheet of coal sections in the Atlas, (Plate VII,) the highest coal bed is the representative of the *Middle Kittanning*. The outcrop of this bed was found on Pistner hill. The face of the coal I did not measure, but its thickness is currently reported to be 2 feet. The bed immediately below this is the representative of the *Lower Kittanning*, and is identical with the bed mined by the St. Mary's Coal Company, at the Cascade mines, and the *C bed* of the North-western Mining and Exchange Company. In *Johnson Run basin* this bed is now being mined by the latter company at the Bucktail mines, where it has generally been known as "*Kane's Gas Vein*."

That portion of Mr. Lesley's report based upon his personal examinations made in the summer of 1864, aided by Mr. E. Burlingame, has been borne out by subsequent developments. The conclusions deduced from a correlation of his observations with those previously reported by Mr. Dalsen are in a measure misleading, from the fact that the results of Mr. Dalsen's examinations have not been substantiated by those obtained by the present Survey. It is due to Mr. Lesley to state that his report was based on a purely reconnaissance survey, and in view of this fact, his conclusions bear most creditable testimony to his high skill and cultured judgment as a practical geologist. To quote from his report, he says :

"In making the first of the following sections, (Johnson Run tract,) I would say that, owing to the wildness of the country, the roundness of the hills, with but few terraces, the almost entire absence of rock exposures in any force, and the few examinations made, it will be necessarily imperfect, but accurate enough to warrant the investment of capital in a thorough examination."

In referring to the *Johnson Run*, *Toby*, and *Bennett's Branch basins*, he says :

"All these basins have yet to be studied, and I sincerely hope one day will be, as their value must be great, lying as they do along the line of a great thoroughfare which is already causing settlers to flow into these hitherto almost unknown regions, to improve and beautify them."

"*Kane's gas vein*" has been considered by many authorities to be very much higher in the coal measures than what has now proven to be the same bed opened in the other localities referred to. Mr. Lesley, however, considered this bed to be the first one above the *Ferriferous limestone*, which is represented by the limestone opened at Kane's quarry. Although this conclusion was not generally accepted, yet the force of it was appreciated by many of the local geologists, and in their efforts, made to harmonize the *Johnson Run section* with that at *Clermont in McKean county*, at *St. Mary's*, and in the *Toby basin*, they concluded that the coal beds opened in these localities were very much lower in the series than those in the *Johnson Run basin*. One of the principal reasons which has been given for this conclusion has been the fact, that nowhere in the other basins was the development of the limestone bed found to be as great as that at Kane's quarry.

The limestone bed on the Wilcox farm opposite Clermont was assigned an indifferent position, very much below the *Kane limestone*; possibly one of the limestones which has been assigned to the Tionesta group lying between what has been called the "TIONESTA SANDSTONE" and "GREAT CONGLOMERATE No. XII."

The name Tionesta has been variously assigned to the JOHNSON RUN SANDSTONE and KINZUA CREEK SANDSTONE in different localities, and the *Ferriferous limestone*, when found of very poor quality and associated with very thin inferior coals, has been assigned to what has been called the *Tionesta group*. The name Tionesta, however, is not recognized by the Survey as designating any special strata. It has produced great confusion in the coal measures, and should be expunged from all the sections.

Gen. Kane considered that the upper bed mined at Clermont, which in Report R was designated as the *Clermont*

bed and in this report is called the *Clarion bed*, was 140± feet below the *Kane limestone* in the *Johnson Run basin*. At Clermont this bed is 32 feet below the *Wilcox farm limestone*, and in consequence the *Wilcox limestone* was considered by Gen. Kane to be at least 100 feet below the *Ferriferous limestone* at the Kane quarry.

This conclusion was one of such great importance, as affecting the value of coal lands in Elk county, that Prof. Lesley made a personal examination of the ground in McKean and Elk counties, in my company, in the fall of 1878, and confirmed the conclusions at which I had already arrived.

From a personal study of the reports of Mr. Joseph Lesley, I would hesitate to infer that any other conclusion was really ever hinted at by him, as to the identity of the limestones. It has been frequently inferred, by local geologists, from a study of his reports that he believed the *Kane quarry* (*Ferriferous*) *limestone* was very much superior, geologically, to the Clermont and lowest limestone bed found elsewhere in the Elk county basins.

The greatest development of the *Ferriferous limestone* which has been exposed anywhere in Elk county is at General Kane's quarry, west of the road leading from the Catholic church to J. Pistner's, near the line separating warrants 3295 and 3296. The following section of the bed was made at this point (Fig. 3, page 68):

1. Gray slate,		—
2. Rotten greenish gray limestone,	3′	
3. Gray shale,	8′	
4. Iron ore,	1′	
5. Hard massive blue limestone,	7′	11″
6. Slate,	1′	
7. *Coal*,	1′	4″
Total,	22′	3″

At the time this section was measured, in 1879, considerable limestone was being quarried to burn in the adjoining kiln. The face of the upper three foot bed was not seen, and the stone from it, was "grubbed" in loose, partly weathered pieces immediately along the outcrop. In a number of sections which have been made of the *Ferriferous limestone* at

this point, this upper bed is not represented, probably from the fact that prospecting had not been done in search of any other limestone, than that exposed immediately alongside of the kiln. The shales immediately underlying the lower bed are slightly calcareous. The lower bed is extremely hard and possesses an irregular conchoidal fracture. A specimen was collected from each bed for analysis. That from the upper bed was fine-grained and very brittle, more or less stained with iron oxide; reddish gray. That from the lower bed was rather fine-grained; brittle; somewhat mottled with calcite; dark bluish gray. The analyses, as reported by Mr. McCreath, were as follows:

	Upper bed.	*Lower bed.*
Carbonate of lime,	94.357	94.107
Carbonate of magnesia,	1.634	1.369
Oxide of iron and aluminum,	1.638	1.626
Phosphorus,	.031	.063
Silicious matter,	1.630	2.200

The general appearance of the two limestones, as quarried on the ground, is quite different; that quarried from the upper bed is generally considered to be the poorer stone. The analyses, however, show the upper bed to contain one quarter of one per cent. more carbonate of lime, and a little over one half of one per cent. less silicious matter. There is a close agreement between the percentages of the other constituents in the two limestones.

Mr. McCreath, in referring to these analyses, says: "These analyses correspond to the general averages of the *Ferriferous limestone*, which is never magnesian, at least so far as our analyses show."

The limestone at this locality is of exceptional thickness, but its section here is no guarantee that the bed will be found as thick, or composed of as pure limestone, in the immediate locality. Considerable prospecting has been done in its search, but at no point has the bed been opened with a section to compare in any way with that at Kane's quarry. Some of those who have searched for the bed, elsewhere, believe that it is not only of abnormal thickness at the quarry, but that the limestone seen on the exposure is

not absolutely in place. While the quarry bed is unusually thick, I believe that the stone at the quarry lies in the true position of the bed. The dip is excessive and much greater than the general dip of the strata in this part of the basin. This dip may be produced by a crack in the bed a short distance back of the face of the exposed stone, or by a slight undermining of the shale beneath it, through natural weathering. To ascertain this fact, however, would require considerable prospect work at the quarry.

The coal bed (*Ferriferous coal bed*) which occurs underneath the limestone, and which was below water level whenever I visited it, but from which I obtained pieces of coal by picking below the surface of the water, is a frequent accompaniment of the *Ferriferous limestone*, and has been found in other localities in the county in the same relative position, notably in the *Toby Creek basin* in Fox township. This coal bed has never been found of sufficient dimensions to prove workable.

The *iron ore* which is found below the upper lime bed is also a frequent accompaniment of the *Ferriferous limestone*. The thickness, which I have assigned to it, is one foot, although it has been variously reported by reliable authorities to be 1 foot 6 inches thick. Sanguine hopes have been built upon the existence of this iron ore bed, for the manufacture of iron. In fact a number of reports, which have been made upon the minerals of this section, claim that this coal basin contains all necessary materials for the manufacture of iron, and hopes have been entertained that iron furnaces would be ultimately erected. Such a hope could certainly *never* be realized. In the first place there is not a sufficient quantity either of limestone or of ore to warrant the erection of the smallest stack, nor are the composition of either the local ore, flux, or fuel of such a character as would possibly make the manufacture of iron from them remunerative.

There are no two strata in the coal measures of Elk county which I have found of more variable and sporadic character than the *Ferriferous limestone* and the accompanying iron ore, which is sometimes a carbonate and some-

times a brown hematite, and I do not hesitate to caution any one against engaging in any project looking to the manufacture of iron.

The horizon marking the position of the *Ferriferous limestone* underlies a considerable area in the *Johnson Run basin*. The outcrops of the stone, which were found, were so few and scattered that it was impossible to outline it with much exactness on the geological map of the county.* Mr. Lesley estimated that 140 acres of the Roberts' lot were underlaid by it, and it is possible that the entire area underlaid by it between the East and West Clarion creeks would approximate 9 square miles. This area has been estimated with considerable care, more particularly to convey an idea as to the area underlaid by the workable coal beds occurring in the section above and below the limestone.

The *Lower Kittanning bed*, which occurs 40 to 50 feet above the limestone, would not underlay as great an area, while the area of the *Clarion coal bed*, which occurs about 30 feet below the limestone, and the *Alton beds*, which occur about 110 feet, for the *Upper coal bed*, and about 130 feet, for the *Lower coal bed*, below the limestone, would, of course, very much exceed that given for the limestone. To determine these respective areas with any precision would require that a great many openings should be made along the outcrop of each bed, and that these should be located on a careful contour line map of the entire area. A number of estimates have been made of these areas, and numerous inquiries have been made of the Survey as to the amount of coal which underlies special tracts in the *Johnson Run basin*, to determine which, with any exactness, would require a more detailed exploration than it was possible for the Geological Survey to make.

Bucktail mines and surrounding territory.

The *Lower Kittanning coal bed* has been opened at the Bucktail mines on the Roberts' lot. The elevation of the bottom of the bed at the lower of the two openings which

*This remark would apply equally to other areas in the county where the outcrop of the limestone is shown on the geological map.

had been made up to August, 1883, when the mines were visited, is 1900 feet.* The dip of the coal bed is about 2.5 to 3 feet per hundred a little to the east of south.

The two main gangways are about twelve yards apart, running nearly north for a distance of 135 feet, when they deflect to the east and continue on a course from 22° to 35° east of north for a distance, at the time the mines were visited, of about 275 feet. The gangways run with the face of the coal, and the cross-headings are driven north-west on the butt of the coal in a direction about north 38° west.

The bed varies from 2 feet 8 inches to 2 feet 10 inches in thickness. The average thickness may be said to be 2 feet 9 inches, although 5 places had been opened prior to November, 1883, where the bed contained only 1 foot 4 inches of good coal.† The floor is a soft homogeneous fire-clay 2+ feet thick, and the stratum above the bed is composed of rather soft gray slate which makes a good roof; 4 feet of it have been cut through. The best coal in the bed is taken from its center, and is about 10 inches thick, and generally free from sulphur; 10 inches of the top coal above this bench is quite sulphurous and hard to mine. The lower portion of the bed, which has an average thickness of 1 foot 3 inches, contains more or less sulphur, but less than the upper bench. This lower bench is reported by the miners to sweat after a rain storm, and the water filtering through it dissolves considerable iron and renders the coal sometimes quite rusty. This, however, is a peculiarity which is probably only maintained near the

*This elevation was determined by barometer, and is based upon the elevation of the Philadelphia and Erie railroad track at Wilcox, as are all the elevations between the latter place and Clermont. Mr. W. H. Harris, mine foreman, informed me that the elevation of this same mine opening, based upon the profile of the railroad tract at the chutes, was 1905′. The elevation of track at the chutes as determined by the barometer, is 1860′. Although the elevation in front of the Bucktail chutes, as determined by the engineers, is not known, those given in the report can readily be reduced by adding or substracting the difference between the elevation determined here by the barometer and that by the railroad engineers, when the latter elevation shall be known. The barometric heights are sufficiently accurate for all practical purposes in geological work. They must, however, be accepted with a reserved confidence as compared with the heights determined by the engineers' level.

†The coal bed in these places is evidently locally "*squeezed.*"

outcrop, where there is not sufficient cover to the bed to protect it from the surface water. The sulphur in both the top and bottom benches is generally "lime" or "ball" sulphur, occurring in lenticular masses, except in the lower 4 inches of the bottom bench, where the sulphur is flaked. This lower portion of the bed is frequently slaty and too poor to be mined.

At an opening east of the Bucktail mines the *Lower Kittanning bed* shows a thickness of 4 feet. This, however, is no doubt an unusual thickness. It is generally claimed that the bed is exceptionally thin around the Bucktail mines. I was informed by Gen. Kane (Sept., 1883) that the bed has an average thickness of 4 feet 2 inches south of the mines, near the southern boundary of the Roberts' lot, out of which it would be safe to assume that 3 feet 6 inches of coal can be mined. In 1876 an opening was visited which showed, a few feet back from the outcrop, a thickness of 3 feet 6 inches of coal.

With these varying records as to the thickness of the *Lower Kittanning coal bed* in this vicinity, it would probably not be safe to assume the workable thickness, over any considerable area, to be greater than that which has already been developed in the Bucktail mines, until a greater thickness shall be actually proved by development.

The same coal bed has been opened back of the coal chutes at an elevation of 10 feet above the mine mouth. This shows a general dip to the measures, in this vicinity, of about 1 foot per hundred feet, in a direction nearly due east. This, however, is not in the line of maximum dip. The elevation of the top of the limestone at Kane's quarry north of these mines is 1920 feet above tide, which is greater than the elevation of the Bucktail mines. The place of the coal bed, however, is 40 feet above the limestone, so that there is a considerable dip in the strata from the limestone to the coal mines.

The *Lower Allon coal bed* is what has sometimes been locally called the "*Shaft*" *bed*, and has been opened on the east side of the road leading from the Bucktail mines to

St. Mary's, at an elevation of 1855 feet. The bed at this opening measures 3 feet 6 inches thick.

In the woods, on the run south-east of the above openings, at an elevation of about 20 feet above it, the *Upper Alton bed* has been opened, and measured 3 feet thick. This latter bed has been locally called the "*Lower Cannel coal.*" The section of the strata in the vicinity of these beds, as measured by Mr. Lesley, is as follows (Fig. 4, page 68):

1.	"*Lower Cannel*" *coal*,	3′
2.	Shaly sandstone,	18′
3.	Hard, gray, micaceous sandstone,	
4.	Shaly sandstone,	
5.	Blue shale,	
6.	Brown shaly sandstone,	
7.	Black slate,	
8.	Shale,	
9.	"*Shaft vein*,"	3′ 6′
10.	Sandstone,	—
	Total,	24′ 6″

A bed has been opened at what has been known as the "*Stone Hill opening*," at an elevation of 1785 feet. This opening had fallen shut when visited, so that I am unable to assign any thickness to the bed. The distance from this opening to other exposures is such that it was impossible to identify the bed. It is probable, however, that it is the representative of the *Upper Marshburg bed.*

West of the forks of the road, in the eastern part of warrant 2610, a coal bed outcrops at an elevation of 1970 feet, which is probably the *Lower Kittanning coal.* At Weitoff's farm, near the north-western corner of warrant 2564, the same bed has been opened at an elevation of 2005 feet. The coal bed at the former locality is overlaid by a shaly sandstone, and underlaid by a fire-clay, which forms a distinct swamp to the west. The fire-clay bed is reported to be between 5 and 6 feet thick. But a short distance west of this opening, what would appear to be the outcrop of another coal bed was located, at an elevation of 1940 feet. This may possibly be the representative of the *Ferriferous coal* underneath the limestone, or the *Clermont coal.* Sufficient exposures were

not found to determine the dip of the strata here or the identity of the bed.

At *Westcott's old coal drift*, south of the road forks at the Catholic church, the *Clarion bed* has been opened. This same bed has been cut by the railroad 300 feet south of the road crossing at Rasselas station. The *Clermont coal bed* in this locality varies from 2 feet 6 inches to 3 feet thick. This same bed outcrops also in the road half a mile east of this point, towards the Clay farm, at an elevation 20 feet higher. This bed has locally been known as the "*lime coal.*"

Along the road in front of M. Weidert's house, near the Catholic church, a carbonate of iron outcrops. The iron balls here are numerous and so heavy, for an outcrop, that the deposit has been esteemed by local geologists as one of great value, and one which could be looked upon as being capable of supporting profitable iron operations. No development has been made of this bed to prove what it is really worth, so that it is impossible to make a final statement as to whether ore in sufficient quantity could be mined to a profit for local consumption, or ore of sufficient purity could be obtained to bear shipment to distant iron furnaces. Similar outcrops were found in a number of other localities in the district, although they were not as promising as at this point; nothing was seen, however, which would lead me to conclude that any extensive deposit of carbonate of iron exists either here or elsewhere.

One thousand feet north of the road forks, in the northern part of warrant 3291, coal has been shafted on, which has been found to be 3 feet thick, with a fire-clay floor, underlaid by a hard massive sandstone. The elevation of the shaft is about 1775 feet. This coal bed is without doubt the *Clarion*, and the loose pieces of sandstone which are found in the vicinity of the shaft, and at a lower level, have evidently come from the JOHNSON RUN SANDSTONE. In the western part of warrant 3293, and north of the road leading to Wilcox, a coal bed has been drifted on at *Johnson's opening*, the elevation of which is 1740 feet. The section of the bed is as follows (Fig. 5, page 68):

1. Sandstone, (roof,)	–	
2. *Coal*,	1′	6″
3. Slate,		1″
4. *Coal*,	1′	6″
5. Fire-clay, (floor,)	–	
Total,	3′	1′

This coal is without doubt the representative of one of the *Alton beds*. The coal has been locally called the "*Shaft*" *bed*. Few exposures were found anywhere in the vicinity of the opening, and it was impossible to determine with any certainty the identity of the bed. It would seem, however, more probable that it is the *Alton Lower bed* than the *Alton Upper bed*.

Other coal openings have been made in the *Johnson Run basin*, north-west of the East Clarion, which were visited. At all of them the drifts had fallen shut, so that little certain information could be obtained as to what had actually been found when the openings were made, so that it is a matter of no importance that they should be mentioned here. A comparison of their elevations, with those which have already been referred to, go to confirm the structure which I have made out for this district.

The conclusions, to which all the observations made here lead, are: First, that the highest workable coal bed found is the *Lower Kittanning;* Second, that, other than this bed, the *Clarion* and two *Alton beds* should alone be expected to be found of workable dimensions; Third, that the only limestone which exists in the coal measures is the *Ferriferous*, which outcrops at Kane's quarry; Fourth, that no *iron ore* of economical value can be expected to be found, as far as past developments would indicate; Fifth, that it would be unsafe to conclude from developments in the *Lower Kittanning*, *Clarion*, and *Alton beds* in other localities in the county that coal could be mined from these beds in the *Johnson Run basin* which should be of a quality similar or superior to that mined from the same beds elsewhere.

The only developments which have been made in this basin in the *Clarion* and *Alton Upper beds* have been at Clermont, in McKean county. The development which has

already been made of the *Lower Kittanning bed* at the Bucktail mines indicates, as far as we know, very nearly the character of coal which might be expected from this bed in the immediately surrounding areas. Considerable prospect work would have to be done in the *Clarion* and *Alton beds* in the *Johnson Run basin* to prove the character of the coal which might be expected to be mined from them here.

The coal areas along the eastern margin of the *Johnson Run basin*, which in McKean county are represented by the areas known as the Butterfield* purchase, and the Backus and Chadwick lands, are more broken up into individual and isolated patches than those contained nearer the center of the basin north-west of East Clarion creek. This applies to that portion of the basin east of the Instantur and Clarion creeks, the general character of which is defined on the Elk map, in eastern Jones and north-western Benzinger township.

Field tract and surrounding territory.

The outlines of the COAL MEASURES and MAUCH CHUNK RED SHALE No. XI in eastern Jones and northern Benzinger townships are less definitely determined than any of the geological outcrops which are shown on the Elk county map (Plate II). This area, when visited a number of times in 1877 and 1878, was a dense forest mostly composed of hemlock. Very little prospecting had been done in search of coal beds, and the maps of this area which could be obtained were so questionable *that the best that could be done*, without the construction of a more accurate and detailed map by the Survey, which was not permitted by its limited resources, *was to sketch in the geological features.*

A more recent survey of six warrants in the headwaters of Straight creek (Nos. 2592, 2624, 2612, 2598, 2611, and 2614) has been made by Mr. Robert P. Field, Mining Engineer, with great care, and the records of six prospect drill holes, sunk in search of the coal beds under the direction of Mr. Field,

* Report R, page 109.

have disclosed facts which *make it necessary to modify* very much the *sketch of the geology* of these six warrants contained on the *Elk county geological map*. Mr. Field has generously placed at the disposal of the Survey all the facts which he has obtained. Although Mr. Field is a part owner of these lands, and his facts, in his opinion, would indicate that the economical value of these lands, for mining purposes, is very much less than has formerly been supposed, yet he has shown a willingness, of uncommon occurrence among property owners, to have them published by the Survey.

My personal knowledge of the portion of the *Johnson Run basin* east of the East Clarion, obtained from frequent visits made to this section in company with Mr. Graham Macfarlane, former superintendent of the Buffalo Coal Company's mines at Clermont, Captain A. A. Clay, John Heitman, and my aid, Mr. A. W. Sheafer, has enabled me to place a interpretation upon Mr. Field's facts slightly different from that held by himself. Although the value of this tract for coal mining must be questioned, the *facts so far as obtained* are *not sufficient* to condemn it. A subsequent visit to this section in August, 1883, enabled me to obtain information which permits me to put implicit confidence in all the facts which Mr. Field obtained, through his personal examinations, or those which were obtained by others whose work he directed. In any event, final judgment can not be passed upon these lands until the questionable thicknesses of the coal beds, as revealed by the drill, shall be confirmed by drifts driven into the beds for some distance back from their outcrop.

The north-eastern portion of this area next adjoining McKean county, is topographically, directly connected with the Buffalo Coal Company's tract, the map of which was published in the Atlas of Report R, McKean county. Geologically, however, the area would seem to be more intimately connected with the Butterfield tract, which lies to the east of the Buffalo Coal Company's mining tract, in Sergeant and Norwich townships in McKean county.

Although the geological facts, reported on in Report R, for this tract, cannot be taken as conclusive evidence of what may

JONES TOWNSHIP.

Fig. 6. p. 85.
Field Tract.

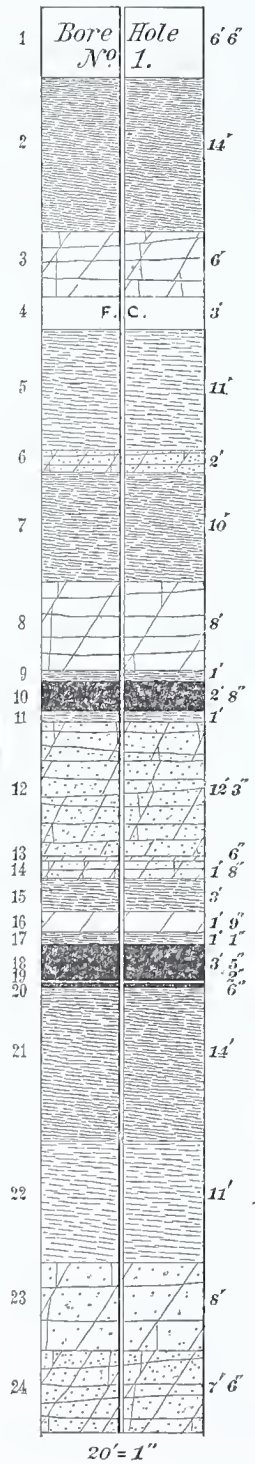
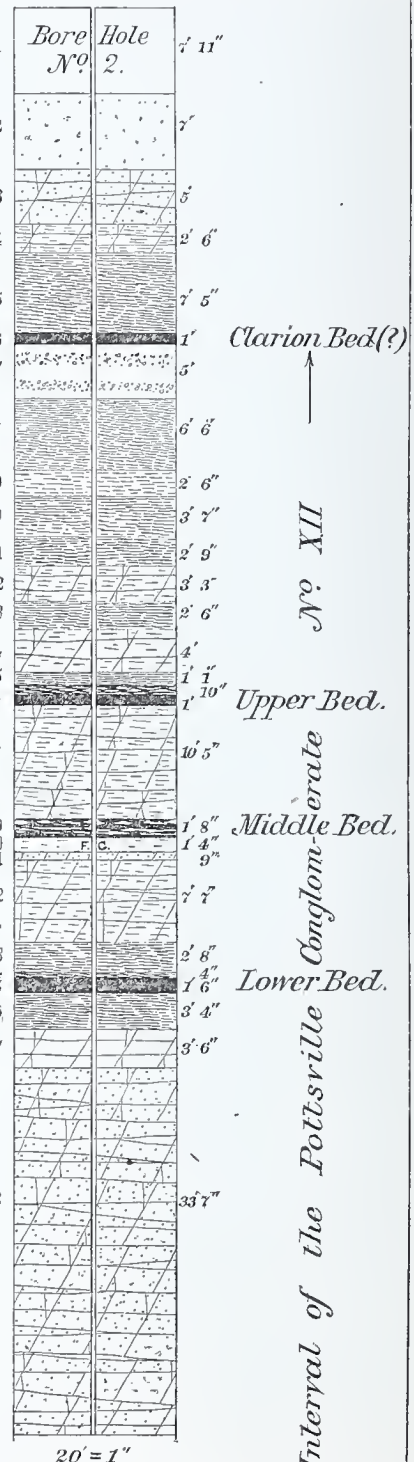


Fig. 7. p. 87.
Field Tract.



be expected to be found in Elk county, yet, from the fact that both areas occupy nearly the same relative position to the axis of the *Fifth Bituminous basin* and the anticlinal separating it from the *FourthBituminous basin*, it would appear that they might reasonably bear a greater similarity one to the other than the coal areas nearer the center of the synclinal.

The actual development, which has been made of the coal beds in Elk county, would lead us to suspect, that, as a rule, thicker beds and better coal will be found nearer the center of the basin. If such shall ultimately prove to be the case, it will naturally suggest an important fact connected with the dynamical geology of the region. Reference has already been made to this in the general description of the structure of the anticlinals and synclinals.*

Mr. Field's topographical sketch map, constructed from compass lines and instrumental profiles, supplemented by barometric elevations, has been connected, by him, with the topographical map of the Buffalo Coal Company's estate, and is published in the Atlas accompanying this report (see Plate IX). The records of the prospect bore holes made by the Buffalo Coal Company and Mr. Field are contained below.

Bore hole No. 1 (Fig. 6, page 84).

Location from south-east corner of warrant 2624, west 11,513 feet and north 405 feet.

Top of drill hole above ocean, in feet=(1900'†+135'.28) 2035'.28.

1. Pipe,	6′	6″	to	6′	6″
2. Black slate,	14′		to	20′	6″
3. Bastard rock,	6′		to	26′	6″
4. Fire-clay,	3′		to	29′	6″

*After the publication of the McKean report, Mr. N. F. Jones, who had superintended the drilling of the bore-holes on the Backus and Chadwick tract, east of the Buffalo Coal Company's land, questioned the correctness of the brief reference which was made to the records of these drill-holes in the McKean report. Mr. Jones published a pamphlet on the subject, which was subsequently replied to by Prof. Lesley and myself; these letters are published as an appendix to this report, to which the reader is referred.

† Mr. Field's elevations are based upon the datum of the Buffalo Coal Company's surveys, which is 1900 feet above tide. (See Report R, page 131.)

Fig. 8. p. 88.
Field Tract.
Bore Hole No. 3.

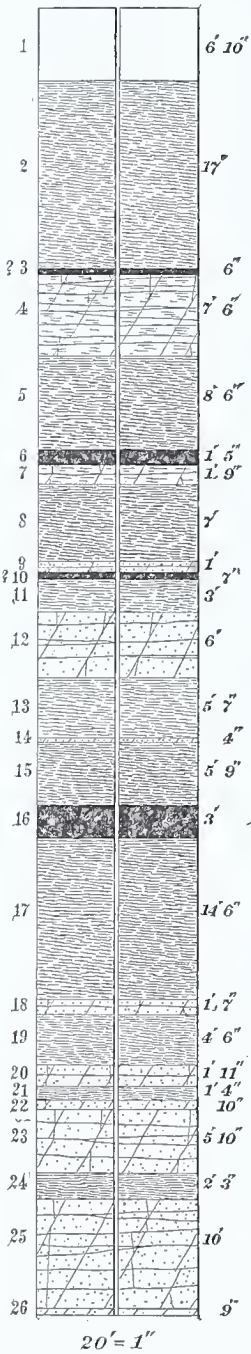
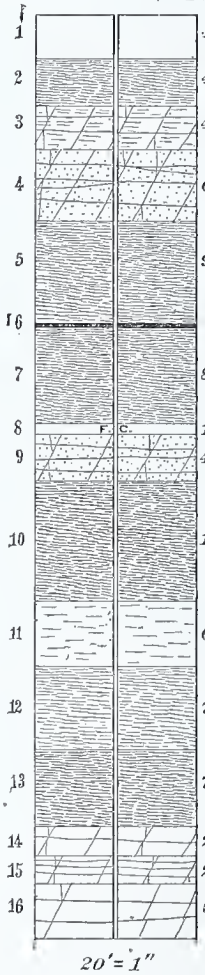


Fig. 9. p. 89.
Field Tract
Bore Hole No. 4.



Alton Coal Group.

Interval of Pottsville Conglomerate No. XII.

All the Field Tract bore holes have been sunk with a rope drill. It is often impossible to obtain exact information as to the thickness and character of strata, particularly coal beds, from holes drilled in this way.

5.	Light slate,	11′		to	40′	6″
6.	Gray sandstone,	2′		to	42′	6″
7.	Black slate,	10′		to	52′	6″
8.	Bastard rock,	8′		to	60′	6″
9.	Black slate,	1′		to	61′	6″
10.	*Coal, soft,*	2′	8″	to	64′	2″
11.	Light slate,	1′		to	65′	2″
12.	Gray sandstone,	12′	3″	to	77′	5″
13.	White sandstone,		6″	to	77′	11″
14.	Dark sandstone,	1′	8″	to	79′	7″
15.	Black slate,	3′		to	82′	7″
16.	Soapstone,	1′	9″	to	84′	4″
17.	Black slate,	1′	1″	to	85′	5″
18.	*Coal bed,*	3′	5″	to	88′	10″
19.	White slate,		2″	to	89′	
20.	*Coal bed,*		6″	to	89′	6″
21.	Black slate,	14′		to	103′	6″
22.	White slate,	11′		to	114′	6″
23.	Coarse sandstone,	8′		to	122′	6″
24.	White sandstone,	7′	6″	to	130′	

The coal bed 2 feet 8 inches thick (stratum No. 10) is the representative of the *Alton Upper coal*, or that which has been mined by the Buffalo Coal Company at their Instantur opening. The coal bed 4 feet 1 inch thick (strata Nos. 18, 19, and 20) is the representative of the *Alton Lower bed.*

Bore hole No. 2 (Fig. 7, page 84).

Location from south-east corner of warrant 2624, west 9754 feet and north 340 feet.

Top of drill hole above ocean, in feet=(1900′+162.′44) 2062′.44.

1.	Pipe,	7′	11″	to	7′	11″
2.	White sandy fire-clay,	7′		to	14′	11″
3.	Yellow sandstone,	5′		to	19′	11″
4.	Slaty sandstone,	2′	6″	to	22′	5″
5.	Dark slate,	7′	5″	to	29′	10″
6.	*Coal* and mud,	1′		to	30′	10″
7.	Yellow clay and gravel,	5′		to	35′	10″
8.	Gray slate,	6′	6″	to	42′	4″
9.	Black slate,	2′	6″	to	44′	10″
10.	Dark slate,	3′	7″	to	48′	5″
11.	Black slate,	2′	9″	to	51′	2″
12.	Slaty rock,	3′	3″	to	54′	5′
13.	Black slate, gritty,	2′	6″	to	56′	11″
14.	Gray rock, slaty,	4′		to	60′	11″
15.	Black slate,	1′	1″	to	62′	
16.	Sulphur and *coal*,		10″	to	62′	10″
17.	*Coal*,	1′		to	63′	10″
18.	Gray rock, slaty,	10′	5″	to	74′	3″

19. Sulphur and *coal*,	1′	8″	to	75′	11″
20. Fire-clay slate,	1′	4″	to	77′	3″
21. Gray sandstone, hard,		9″	to	78′	
22. Gray rock, slaty,	7′	7″	to	85′	7″
23. Black slate,	2′	8″	to	88′	3″
24. Sulphur,		4″	to	88′	7″
25. *Coal*, bony,	1′	6″	to	90′	1″
26. Black slate,	3′	4″	to	93′	5″
27. Black rock,	3′	6″	to	96′	11″
28. Gray sandstone, very hard,	33′	7″	to	130′	6″

This record is one of the most important which has been drilled in this area, since it establishes the relationship of the *Clarion coal bed* (stratum No. 6), which is but 1 foot thick, the *Alton Upper bed* (represnted by strata Nos. 15, 16 and 17) the *Alton Middle bed* (stratum No. 19), 1 foot 8 inches thick, and the *Alton Lower coal bed* (stratum No. 25), 1 foot 6 inches thick.

Bore hole No. 3 (Fig. 8, page 86).

Location from south-east corner of warrant 2624, west 10,600 feet and north 285 feet.

Top of drill hole above ocean, in feet=(1900′+141.′25) 2041′25.

1. Pipe,	6′	10″	to	6′	10″
2. White slate,	17′		to	23′	10″
3. *Coal*, (??)		6″	to	24′	4″
4. Slaty rock,	7′	6″	to	31′	10″
5. Black slate,	8′	6″	to	40′	4″
6. *Coal*,	1′	5″	to	41′	9″
7. Slaty rock,	1′	9′	to	43′	6″
8. Black slate,	7′		to	50′	6″
9. Dark sandstone,	1′		to	51′	6″
10. *Coal*, (?)		7″	to	52′	1″
11. White slate,	3′		to	55′	1″
12. Dark sandstone,	6′		to	61′	1″
13. White slate,	5′	7″	to	66′	8″
14. Sandstone,		4″	to	67′	
15. Black slate,	5′	9″	to	72′	9″
16. *Coal*,	3′		to	75′	9″
17. Black slate,	14′	6″	to	90′	3″
18. Gray sandstone,	1′	7″	to	91′	10″
19. White slate,	4′	6″	to	96′	4″
20. Dark sandstone,	1′	11″	to	98′	3″
21. White slate,	1′	4″	to	99′	7″
22. Dark sandstone,		10″	to	100′	5″
23. Gray sandstone,	5′	10″	to	106′	3″
24. Black slate,	2′	3″	to	108′	6″
25. White slate,	10′		to	118′	6″
26. White sandstone,		9″	to	119′	3′

In this hole the *Alton Upper coal bed* (stratum No. 6), 1 foot 5 inches thick, the *Alton Middle coal bed* (stratum No. 10), 7 inches thick, and the *Alton Lower coal bed* (stratum No. 16), 3 feet thick, were pierced by the drill. A streak of coal was found 16 feet above the upper bed, with a questionable thickness of 6 inches. This might represent one of the riders which are sometimes found in the rocks representing the JOHNSON RUN SANDSTONE, and which occur notably in Lafayette township, McKean county. Mr. Field questions the accuracy of the record, as regards this 6 inch coal streak.

Bore hole No. 4. (Fig. 9, page 86).

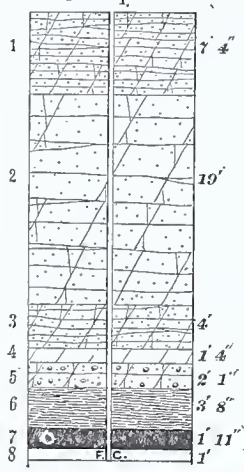
Location from south-east corner of warrant 2624, west 11,893 feet and north 1,045 feet.

Top of drill hole above ocean, in feet=(1900′+119′.83) 2019′.83.

1. Pipe,	4′		to	4′		
2. White slate,	4′	4″	to	8′	4″	
3. Slaty rock,	4′		to	12′	4″	
4. White sandstone,	6′	6″	to	18′	10″	
5. White slate,	9′	4″	to	28′	2″	
6. *Coal*,		4″	to	28′	6′	
7. White slate,	8′	10″	to	37′	4″	
8. Fire-clay,	1′		to	38′	4″	
9. Gray sandstone,	4′	3″	to	42′	7″	
10. Black slate,	10′	11″	to	53′	6″	
11. Soapstone,	6′		to	59′	6″	
12. White slate,	7′	6″	to	67′		
13. Black slate,	7′		to	74′		
14. Dark rock,	2′	8″	to	76′	8″	
15. Soft rock,	2′	6″	to	79′	2″	
16. Gray rock,	5′	1′	to	84′	3″	

In the record of this bore hole but one coal bed (stratum No. 6), 4 inches thick, is reported. That this is a fair report of the condition of the coal measures in the vicinity of the hole may be questioned. The structure which the record exhibits is so very different from that shown in the records of the adjoining holes, that it would seem to be impossible to suggest a satisfactory comparison. It is probable, however, that the small streak of coal passed through may occupy the horizon of the *Alton Upper coal bed.*

Fig. 10. p. 91. *Field Tract. Bore Hole No. 5.*



Ferriferous Coal Bed (?)

Fig. 11. p. 91.
Field Tract.
Bore Hole No. 6.

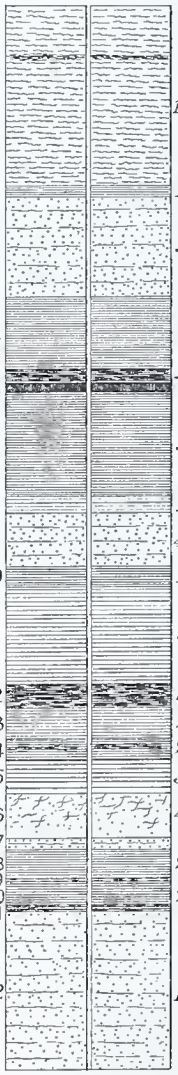
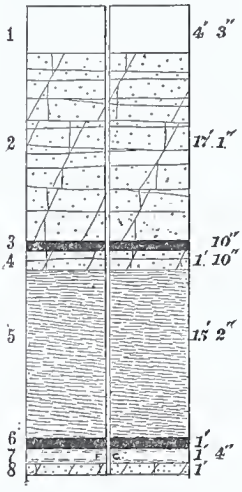


Fig. 13. p. 95.
Field Tract.
Bore Hole No. 8.



Clarion Bed.

Interval of the Johnson Run Sandstone.

Alton Coal Group.

Kinzua Creek Sandstone.

20′ = 1″

Bore hole No. 5, (Fig. 10, page 90).

Location from south-east corner of warrant 2624, west 9,700 feet and north 800 feet.

Top of drill hole above ocean, in feet=(1900′+206′) 2106′.

1. Sandrock, (wash,)	7′	4″	to	7′	4′
2. Brown sandrock,	19′		to	26′	4″
3. Sandrock, (crack,)	4′		to	30′	4″
4. Iron stone and hard rock,	1′	4″	to	31′	8″
5. Hard sandrock, (pebbles,)	2′	1″	to	33′	9″
6. Black slate,	3′	8″	to	37′	5″
7. *Coal*,	1′	11″	to	39′	4′
8. Fire-clay,	1′		to	40′	4″

The coal bed (stratum No. 7) passed through about 1 foot above the bottom of the hole, and which is reported as 1 foot 11 inches thick, *may be* the representative of the *Lower Kittanning bed*, and if so, a comparison of this section with those of bore holes Nos. 2 and 6 would indicate that the strata included between this coal bed and the *Clarion bed* are probably not over 30 or 40 feet thick. There are no facts, except a general thinning of all the coal measures in the *Johnson Run basin* toward the north-east,* which would suggest that the strata between the *Lower Kittanning* and the *Clarion beds*, which are usually from 60 to 70 feet thick, are as thin as 30 or 40 feet in the vicinity of Mr. Field's test holes. I am disposed to consider, therefore, that the coal bed in this section (stratum No. 7) is the *Ferriferous* and not the *Lower Kittanning coal bed.*

Bore hole No. 6 (Fig. 11, page 90).

Location from the south-east corner of warrant 2624, west 9,700 feet and north 1,500 feet.

Top of drill hole above ocean, in feet=2070′.

1. Soil, with wash of coal,	16′	3″	to	16′	3″
2. Dark gray slate,	1′		to	17′	3″
3. Dark gray sandstone,	9′		to	26′	3″
4. Black slate,	6′	6″	to	32′	9″

*This is particularly noticeable in a comparison of the section of the JOHNSON RUN SANDSTONE interval in the Johnson Run section, in the vicinity of Bucktail mines; in the Clermont section; and in the sections of the area covered by the accompanying map (Plate IX), especially section No. 11, of bore hole No. 6.

Fig. 12. p. 93.
Field Tract. Bore Hole No 7.

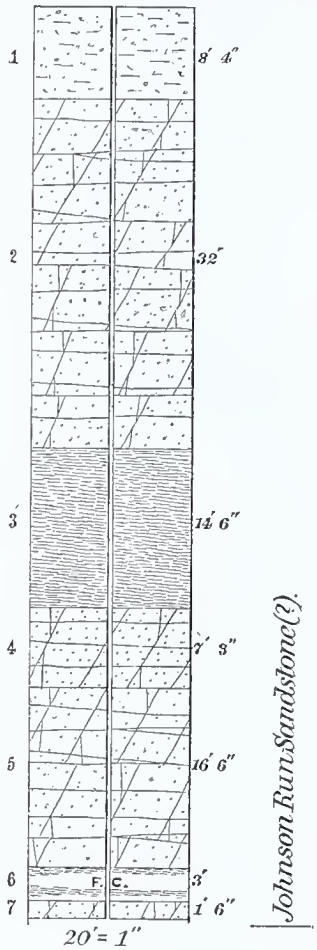


Fig. 18. p. 105.
Pocono No X. Limestone
on
East Clarion Creek,
at mouth of
Ellie's Brook.
Warrant No 2527.

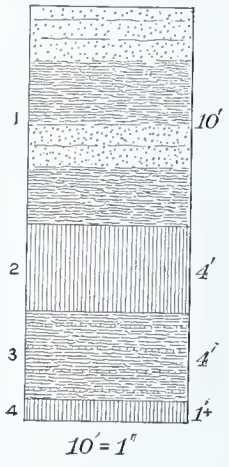


Fig 14 p. 98.
Field Tract.

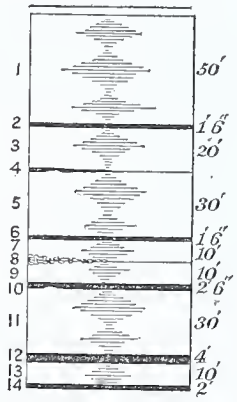


Fig. 15. p. 99.
Field Tract.

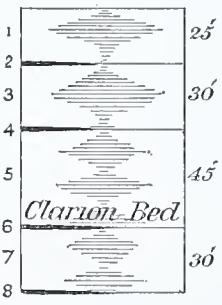
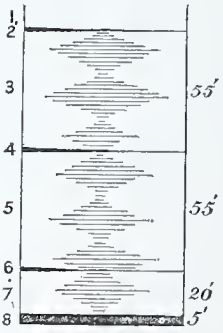


Fig. 16. p. 100.
Field Tract.



5.	Bone and *coal*,	1′ 3″ to 34′	
6.	*Coal*,	9″ to 34′	9″
7.	Black slate,	9′ 6″ to 44′	3″
8.	Gray slate,	1′ 6″ to 45′	9″
9.	Gray sandstone, hard,	4′ 11″ to 50′	8″
10.	Black slate,	1′ 9″ to 52′	5″
11.	Gray slate,	8′ 9″ to 61′	2″
12.	Sulphur and bony *coal*,	2′ 3″ to 63′	5″
13.	Dark gray slate,	2′ 9″ to 66′	2″
14.	Black bony slate,	2′ to 68′	2″
15.	Black slate,	3′ to 71′	2″
16.	Sandy fire-clay,	4′ 2″ to 75′	4″
17.	Gray sandstone, hard,	10″ to 76′	2″
18.	Gray slate,	2′ 9″ to 78′	11″
19.	Sulphur, hard,	2″ to 79′	1″
20.	Black bony slate,	2′ 2″ to 81′	3″
21.	Black bony slate and *coal*,	8″ to 81′	11″
22.	Gray slaty sandstone,	14′ 3″ to 96′	2″

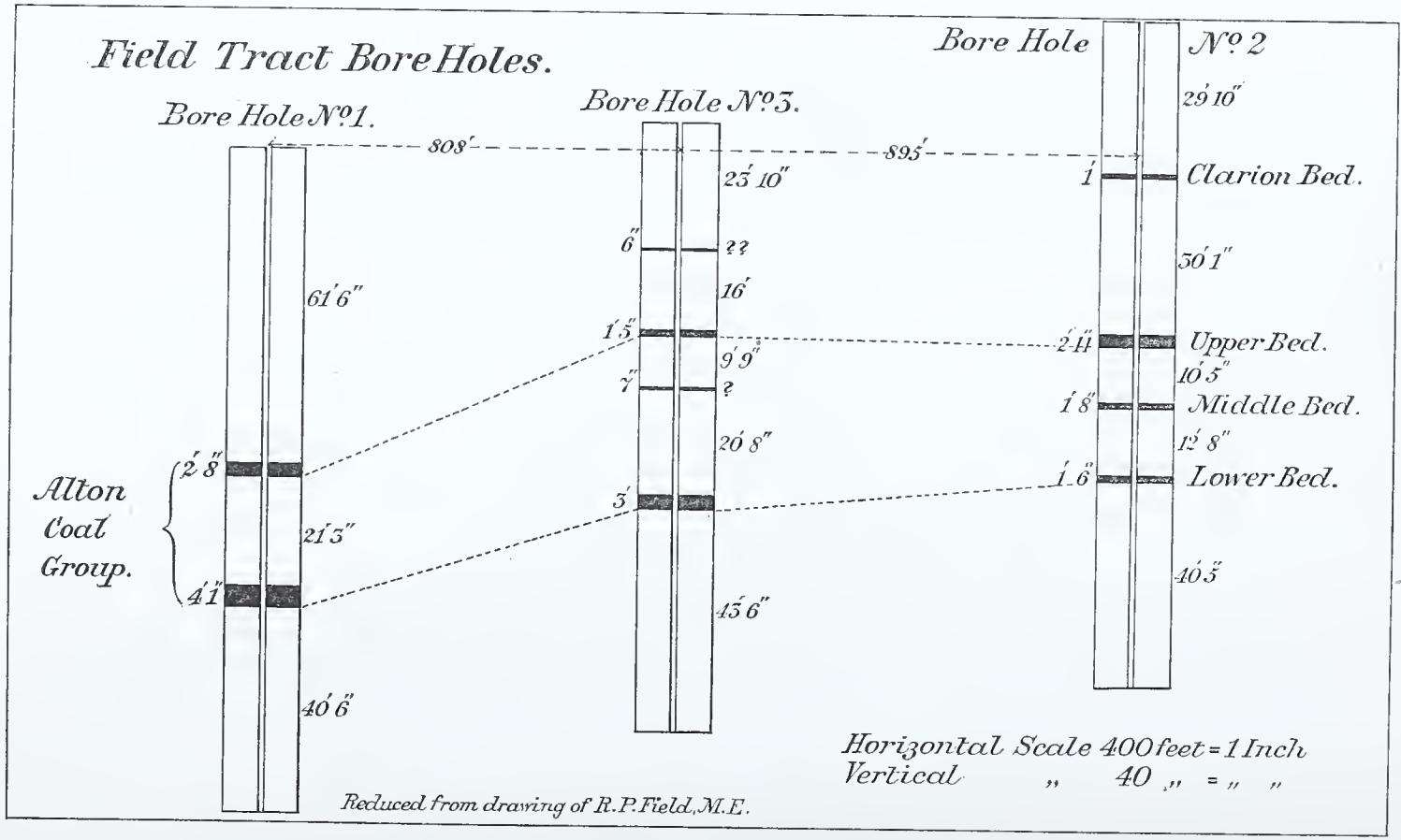
The bone and coal (stratum No. 5) and coal (stratum No. 6) would appear to be the representative of the *Clarion coal bed*, and strata Nos. 12 to 21, inclusive, those of the *Alton group*. If this comparison is correct, as there is very little doubt it is, a notable feature is exhibited, which is shown to some extent by all the sections in this locality, and that is, the unusual character of the rocks between the *Clarion* and the *Alton coal beds*, which compose the JOHNSON RUN SANDSTONE interval. The strata representing the JOHNSON RUN SANDSTONE in this section are only 26 feet thick, and are composed almost entirely of slate, a stratum of sandstone only 4 feet 11 inches in thickness being pierced by the drill about midway between the *Clarion bed* and *Alton Upper bed*. These features are in bold contrast to the section of the JOHNSON RUN interval in the vicinity of the Bucktail mines, where it is from 70 to 80 feet thick, and composed almost exclusively of massive sandstone, which forms some of the rock cities for which that locality is so famous.

Bore hole No. 7, near point A, (Fig. 12, page 92).

Approximate location from south-east corner of warrant 2624, near point A, west 11,840 feet and south 1,635 feet.

Top of drill hole above ocean in feet=(1900′+163′±) 2063′±.

1.	Soil,	8′ 4″ to 8′	4″
2.	Sandstone,	32′ to 40′	4″
3.	White slate,	14′ 6″ to 54′	10″


Field Tract Bore Holes.
Bore Hole No. 1.
Bore Hole No. 3.
Bore Hole No. 2
808'
895'
61' 6"
2' 8"
21' 3"
4' 1"
40' 6"
Alton Coal Group.
25' 10"
6"
??
16'
1' 5"
9' 9"
7"
?
20' 8"
3'
45' 6"
29' 10"
1'
Clarion Bed.
30' 1"
2' 11"
Upper Bed.
10' 5"
1' 8"
Middle Bed.
12' 8"
1' 6"
Lower Bed.
40' 5"
Horizontal Scale 400 feet = 1 Inch
Vertical " 40 " = " "
Reduced from drawing of R. P. Field, M.E.

4. Dark sandstone,	7′	3″	to 62′	1″
5. White sandstone,	16′	6″	to 78′	7″
6. Fire-clay and slate,	3′		to 81′	7″
7. White sandstone,	1′	6″	to 83′	1″

Sufficient definite facts have not been reported in this record to render it possible to determine the exact geological position of the strata through which the drill passed. It would seem probable, however, that the hole stopped before the coals of the *Alton group* were reached. It is hardly possible that drilling was commenced at this hole below the outcrop of the *Clarion bed.* It would appear that the horizon of this coal bed should be found somewhere in stratum No. 3 (14 feet 6 inches thick), which is without doubt the same as stratum No. 2 in bore hole No. 1 (section No. 6). In this case, the *Clarion bed* would have thinned out in the direction of bore holes Nos. 1 and 7, where the drill has passed through its horizon, but coal was not found. The tendency of the *Clarion* and *Alton coal beds* to thin out to a knife's edge in certain directions is not an unusual one, particularly in the northern section of the *bituminous coal fields.* If the comparison of this section with others be a correct one, it serves to caution the coal miner against entertaining an idea that these coal beds will be found of workable thickness over indefinite areas (which are sufficiently elevated to contain the coal beds) in the vicinity of openings, where the beds may be found all that could be desired.

Bore hole No. 8, warrant 2611, (*Fig. 13, page 90.*)

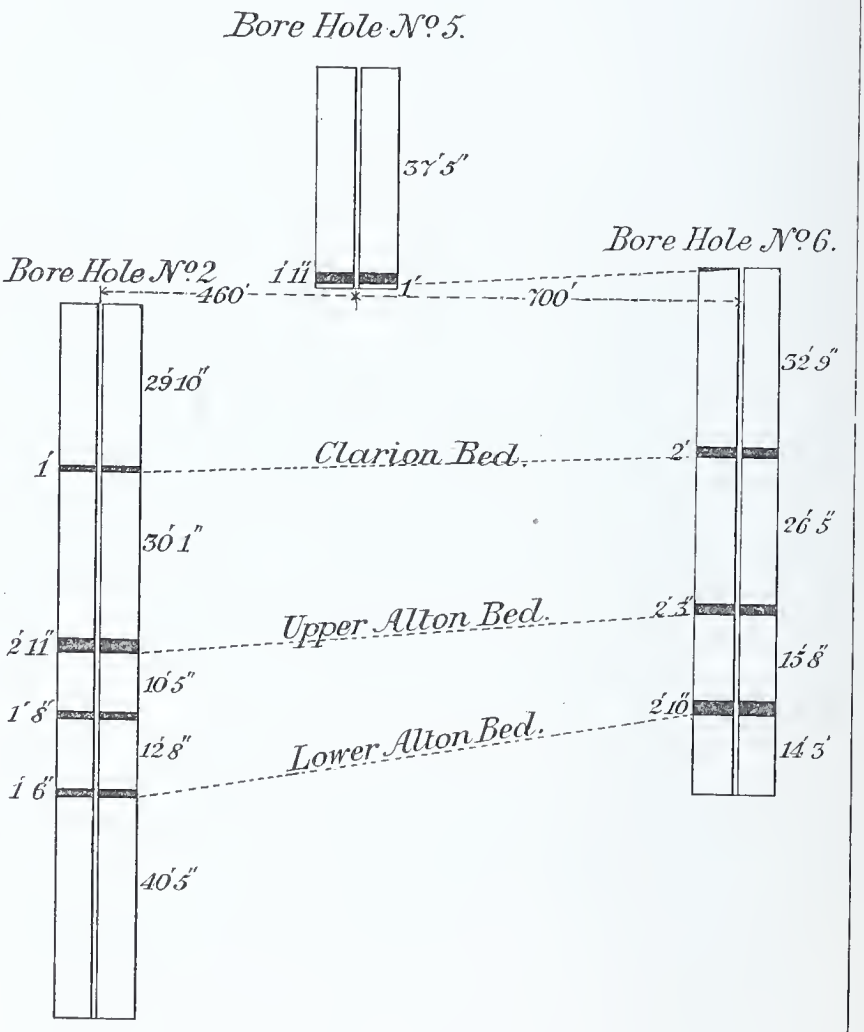
Location from south-east corner of warrant 2624, west 12,414 feet and south 5,700 feet.

Top of drill hole above ocean, in feet=(1900′+106′.19) 2006′19.

1. Pipe,	4′	3″	to	4′	3″
2. Sandstone,	17′	1″	to	21′	4″
3. *Coal,*		10″	to	22′	2″
4. White sandstone,	1′	10′	to	24′	
5. White slate,	15′	2″	to	39′	2″
6. *Coal,*	1′		to	40′	2″
7. Mixed clay and slate,	1′	4″	to	41′	6″
8. Coarse sandstone,	1′		to	42′	6″

This hole was drilled near the mouth of the drift opened

Field Tract Bore Holes.



Horizontal Scale 400 Feet = 1 Inch.
Vertical „ 40 „ = „ „

Reduced from drawing of R. P. Field M.E.

on the east side of the hill facing Spring run, in warrant 2611. The lower bed in the hole is identical with the one opened in the drift, and is, without doubt, the representative of the *Alton Lower bed.*

The *Alton Lower bed* was drifted on about 50 feet from where the above hole was bored, and the bed was reported to be 5 feet thick where opened, but thinned down to 2 feet in a distance of 18 yards, to which the drift was driven; the elevation of the bottom of the bed at the mouth of the drift being 1970 feet.

This sudden change in the thickness of the *Alton Lower bed* is not unusual, and although not generally of frequent occurrence on a tract containing 100 to 200 acres, which would be sufficiently large for a small mining operation, yet it is to be expected, and must, in consequence, affect the value of a tract for mining; since the amount of coal, which can be extracted from under any given area, must necessarily be dependent upon the possibility of the coal bed thinning down to such an extent as to render it unworkable, or of being entirely cut out. The bed is sure to be found again, if the mine gangway, after the bed is lost, is driven across the barren area. The operation is, at the best, however, a hazardous one, since the driving may extend but a few feet, and may go several hundred feet, before the bed be found again of workable dimensions.

The comparison of the sections of these bore-holes, which is suggested by the names assigned to the beds, is shown in the accompanying sections (pages 94 and 96), where the records of the bore-holes have been constructed into vertical columns on a scale of 40 feet to 1 inch.

Few good natural exposures are to be found in this locality, and the facts which have been made use of to construct the following sections were obtained from surface diggings, and the profiles of the hills. From the fact that a coal bed, with its underlying fire-clay, although covered up, generally forms a marked feature in the profile of the hills, it is frequently possible to surmise the existence of a bed. Immediately above the place of the bed the slope is generally quite steep, due to the fact that the bed, with

its overlying slate or fire-clay, generally weathers more rapidly than the harder rocks above them. The fire-clay below a bed generally forms the top of a small terrace. In Mr. Field's sections the position of such a feature is generally indicated by the word "bench," and he has inferred that if search should be made by digging at such points a coal bed might be found.

Section No. 1 constructed from observations made between coal opening marked Q and the hill-top in the eastern part of warrant 2612 (Fig. 14, page 92):

Hill-top.

1.		50′	
2.	*Coal bed* outcrop,	1′	6″
3.		20′	
4.	Bench,	—	
5.		30′	
6.	*Coal bed* outcrop,	1′	6″
7.		10′	
8.	Iron ore outcrop,	—	
9.		10′	
10.	*Coal bed* outcrop,	2′	6″
11.		30′	
12.	*Coal*, opening Q,	4′	
13.		10′	
14.	*Coal bed* outcrop,	2′	
	Total,	171′	6″

The coal bed which was opened here would appear to be the representative of the *Alton Upper bed*, or the same bed as has been mined at the Instantur opening of the Buffalo Coal Company. The elevation of the bottom of the bed is 1970 feet, or practically the same as the elevation of the bottom of the same bed passed through in drilling bore hole No. 1 (elevation 1971 feet.) The "*cannel*" *coal* at the bottom of the section is probably the representative of the *Alton Middle coal bed*. This coal bed, which is shown in drill holes Nos. 2 and 3, is about the same distance below the *Alton Upper* as where found at its outcrop below the opening Q. The coal bed outcropping 30 feet above the opening is the representative of the *Clarion bed*, or the same coal as that which has been worked by the Buffalo Coal Company at their Clermont mines, and drilled through in bore hole No. 2.

It is impossible to define the true position in the coal

measures of the two coal beds, one 20 feet above the Clarion and the other 70 feet. It is probable, that the lower may represent the *Ferriferous coal*, which is frequently found immediately underlying the limestone, and the upper the *Dagus coal bed*. The heights of the intervals, however, between these beds and the *Clarion* do not agree with my observations made in the vicinity. In the eastern part of warrant 2612 several outcrops of the *Ferriferous limestone* were found, which would indicate that the interval between it and the Clarion bed is about 35 feet. The outcrop of the *Lower Kittanning coal bed* was also found not far distant from the limestone; from which it has been inferred that the interval between the limestone and the coal bed above, was probably not over 25 feet. making the interval between the *Clarion* and *Lower Kittanning coal bed* 60± feet.

If the outcrops in Mr. Field's section mark definitely the height of the coal beds, and if these coal beds are the representatives of the *Ferriferous* and *Lower Kittanning* (*Dagus*), it would show considerable variance in the thickness of the rock intervals.

On the south side of Luce run, about 1500 feet south-west of the opening Q, the following section was made (Fig. 15, page 92):

Hill top.

1.		25′
2.	Bench,	—
3.		30′
4.	Bench,	—
5.		45′
6.	*Coal outcrop*,	—
7.		30′
8.	*Coal outcrop*,	—
	Total,	130′

The lowest coal bed in this section has been taken to be the representative of the *Alton Upper bed*, and the bed immediately above this the representative of the *Clarion*. About 2000 feet south-west of the point where this bed was measured, the outcrop of a coal bed was opened at the head of the south branch of Luce run, at an elevation of about 1835 feet. This bed would appear to be one of the *Alton*

beds, probably the *Lower Alton*. The top of the hill is 120 feet above the outcrop of the bed; about 25 feet below the hill top a bench was located which probably marks the horizon of a coal bed.

At an opening near bore hole No. 8 on the western side of Spring run, in the northern part of warrant 2611, the following section was measured (Fig. 16, page 92):

Hill top.

1.		—
2.	Bench,	—
3.		55′
4.	Bench,	—
5.		55′
6.	Bench,	—
7.		20′
8.	*Coal bed*, (opening V,)	5′
	Total,	135′

The elevation of the bottom of the bed at this opening is 1970 feet. This coal is the same as the lower one pierced by drill hole No. 8, and is the representative of the *Alton Lower bed.*

In the eastern part of warrant 2554 a coal bed has been opened at what is known as the *Howard mine*, of the Field Mining Company. This I believe to be the representative of the *Alton Upper bed.* At the opening, which has not been driven in sufficiently far to thoroughly test the thickness or quality of the coal, the bed measured 4 feet 6 inches, the elevation of the bottom of the bed being 1880 feet. The summit of the ridge to the south-east of the opening is about 225 feet above the coal bed.

A careful examination of the district which has been mapped and explored by Mr. Field was made in July, 1878, by Mr. Graham Macfarlane, Mr. John Heitman, Mr. Arthur Sheafer, and myself. Although no coal bed outcrops were dug into, a great many were located where digging had been previously done, and a great many facts obtained, which would support the interpretation which I have put upon those reported by Mr. Field.

In the eastern part of warrant 2612 several outcrops of the *Ferriferous limestone* were found, and below it the out-

crops of two coal beds, both of which had been dug into. The lower one was reported to be 4 feet thick, and the upper one 2 feet thick. These beds were taken to be the representatives of the *Alton Upper* and *Clarion beds* respectively, the interval between them being about 35 feet. The *upper bed*, as nearly as could be determined, was 35 feet below the limestone outcrop.

In the north-western part of warrant 2624, south-west of the small branch of County Line run shown on Mr. Field's map, a coal-bed outcrop was located at an elevation of 2060 feet, the summit near the outcrop being 110 feet higher. This bed was thought to be the *Alton Upper coal.*

On the west side of Instantur creek, and above the mouth of Smith's run, near the center of warrant 2530, in Sergeant township, McKean county, the outcrop of a coal bed has been dug into and shows the coal to be composed of three or four separate benches; its total thickness being about 7 feet. The elevation of the bottom of the coal is about 2000 feet. Below the bed was found the outcrop of a fine-grained, rather soft, white, glistening sandstone, containing a few scattered pebbles, varying in size from $\frac{1}{8}$ to $\frac{1}{2}$ of an inch in diameter, the matrix of the pebbles being more or less stained with iron. This conglomeritic sandstone was taken to be the representative of the KINZUA CREEK, and the coal bed above it the *Alton Lower.*

A little over two miles north-west of the above locality, and about half a mile north-west of the Wilcox and Smethport pike and near the headwaters of Smith's run, this same coal bed has been opened at what has been known as *Clay's Seven-Foot opening.* The elevation of the bottom of the bed, as determined by a level line run to the opening by the Buffalo Coal Company, is (1900′+161′) 2061 feet. The section of the bed, measured in August, 1883, was as follows (Fig. 17, page 104):

1. Black slate, (roof,)		—
2. *Coal,*		6″.5
3. Slate,		0″.5
4. *Coal,*	2′	6″
5. Slate,		2″
6. *Coal,*	1′	

7. Fire-clay,	9″
8. *Coal*,	1′ 11″
9. Fire-clay, (floor,)	—
Total,	6′ 11″

On the hill west of the opening blocks of JOHNSON RUN SANDSTONE are to be found. As nearly as could be determined from careful observations made along the slope of the hills, the sandstone at this point is 50 feet thick. This same bed has been opened 2 miles west north-west from this point, on the left-hand bank of Five Mile run, and between Five Mile and Seven Mile runs. At this latter point Captain Clay reports the bed to be 3 feet 11 inches thick.

A study and comparison of all the facts reported here have lead to the following conclusions:

(1.) The only coal beds which will probably ever be found of workable dimensions are the *Lower Kittanning*, *Clarion*, and the *Alton Upper and Lower*.

(2.) No facts have been obtained relating to the *Lower Kittanning bed*, on the east side of the East Clarion and Instantur creeks, upon which any conclusion can be based, either as to the existence of this bed, its thickness, or the character of the coal which it may contain. Many of the hills appear to be high enough to contain it, since it is generally found in the rock series from 50 to 80 feet above the *Clarion bed.*

(3.) Although it is impossible to encourage any hope that this coal bed would establish a mining value to the properties in this district, the fact that the hills are high enough to contain a considerable area of this coal bed should be sufficient encouragement for further explorations.

(4.) As regards the prospects of finding either the *Clarion or Alton coal beds* of workable size or purity in this locality, I do not consider the facts, at present obtained, of a much more definite character than those relating to the *Lower Kittanning bed.*

Mr. John H. Tate, Superintendent of the Buffalo Coal Company, in referring to the explorations made by his company and Mr. Field and associates, expresses the following view: "I am of the opinion that no coal is to be found that

would pay for working, either on the lands of the Buffalo Coal Company, or on those of Samuel Field, in Elk county."

Although Mr. Tate's view may ultimately prove correct, and the facts so far obtained seem to support it, I would accept it with a well-reserved confidence, until explorations shall be made, not by the churn-drill, but by the diamond-drill, and drifts be driven into the coal outcrops.

The ridges on the east side of the East Clarion, between Straight creek and Middle branch, and Middle branch and Crooked creek, are covered with a dense forest, and few exposures, except of the more massive sandstones, are to be found upon them. A number of coal bed outcrops were found, and the elevations of these, when studied in connection with the general structure of the adjoining portions of the basin, would rather lead to the conclusion that both of these ridges are high enough to contain a considerable area of the geological plane marking the horizon of the *Lower Kittanning coal bed.* Nothing, however, is known with sufficient certainty to enable any conclusions to be arrived at as to the possibility of finding any of the coal beds here in a condition to support a profitable mining enterprise. What little can be ascertained would seem to warrant a thorough exploration, in order to determine more definitely the facts relating to the coal beds.

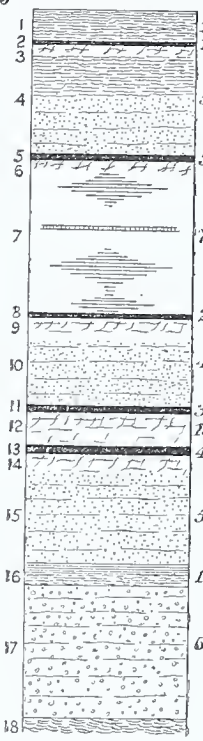
A number of outcrops of the MAUCH CHUNK RED SHALE No. XI were found in the Clarion valley, but it was impossible to determine the thickness of this formation; it would probably, however, not exceed 30 or 40 feet, at the most.

Scattered pieces of a flat pebble conglomerate were found in several places, which evidently came from the broken-down outcrop of the SUB-OLEAN CONGLOMERATE. No actual outcrop of this rock, however, was located. The profile of the hill slopes below the POTTSVILLE CONGLOMERATE would seem to indicate that the interval between the bottom of No. XII and the SUB-OLEAN CONGLOMERATE is, probably, about 60 feet.

Pocono No. X Limestone.

Along the main branch of Straight creek, about half a mile a little east of south of bore-hole No. 8 on Mr. Field's

Fig. 19 p. 106.
Silver Creek Basin between Bridgetown and Montmorency.



Middle Kittanning Bed.

Lower Kittanning Bed.

Horizon of the Ferriferous Limestone.

Clarion Bed.

Alton Coal Group.

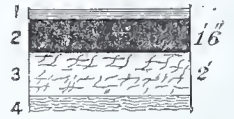
Kinzua Creek Sandstone.

Ocean Congl.

Red Shale No XI.

100' = 1"

Fig. 21. p. 109.
Alton Upper Bed 600' west of "Roadside Opening."



10' = 1"

Fig. 22. p. 113.
Lower Kittanning Bed Montmorency Farm.

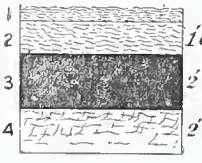


Fig. 23. p. 114.
Lower Kittanning Bed Mill Creek Summit.

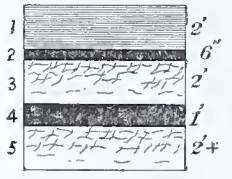


Fig. 17. p. 101.
Lower Alton Bed Clay's Seven Foot Opening.

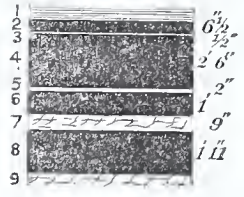
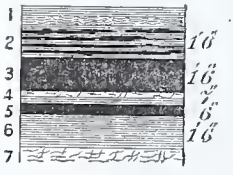


Fig. 20. p. 109.
Lower Alton Bed "Roadside Opening."



10' = 1"

map, he located the outcrop of a *limestone*, which occurs in the POCONO SHALES No. X, about 200 feet below the bottom of the OLEAN CONGLOMERATE. This same *limestone* was found along the eastern bank of the Clarion, in the bed of Ellie's brook,* coming into the Clarion a short distance below the mouth of Straight creek. A section measured at this point is as follows, (Fig 18, page 92):

1. Gray and yellow sandstones, alternating with siliceous and argillaceous shale,	10′
2. Massive blue *fossiliferous limestone*,	4′
3. Yellow argillaceous lime-shale,	4′
4. Less massive *bastard limestone*,	1′+
Total,	19′+

This limestone is probably the same as the *Benezette limestone* found along the road south-west of Benezette village.

Silver Creek Coal Basin.

That portion of the *Johnson Run or Fifth Bituminous coal basin* in south-western Jones and northern Ridgway, west of the Clarion, has been locally named the *Silver Creek basin*, from the fact that most of the drainage of its area is effected through the Silver creek and its main branch, Bear creek.

The coal areas in the vicinity of Montmorency, although in the same basin, are detached by Little Mill creek. On this account, this portion of the basin has been locally named the *Montmorency coal basin*.

Numerous outcrops are seen in *Silver Creek basin*, passing along the road south-west from Bridgetown to Montmorency. In some places, where a coal smut has been found, the horizon of a coal bed is frequently indicated. In some cases, however, pieces of smut have been washed some distance from the outcrop of the bed, and the position of them does not give any clue as to the horizon of the coal from which they came. In fact they are very misleading upon first examination.

*This limestone was discovered during a fishing excursion of a party, of which I was one, composed principally of members of Captain Clay's family. I named the brook after one of the ladies of the party, who excelled in the number of trout caught.

This locality was visited a number of times in company with the late Mr. M. M. Schultz of Wilcox, whose familiarity with the prospecting, which had been done by General Kane and others, enabled him to render me valuable assistance.

The elevation of the Clarion bridge at Bridgetown was determined to be 1476 feet, and the bottom of the OLEAN CONGLOMERATE* was located, in the vicinity, at an elevation of 1540 feet, below which point was found the outcrop of a flaggy shale and sandstone, and loose pieces of red shale, which undoubtedly came from the red shale band shown immediately under the conglomerate in the Bear creek and Silver creek dry holes. Between this point and the highest summit measured, at a height of 1840 feet, near the headwaters of Silver creek, over the *Schultz upper coal opening*, there are included about 325 feet of strata, a section of which is as follows (Fig. 19, page 104):

1.	Shales,	15
2.	*Middle Kittanning coal bed*,	1′ 6″
3.	Fire-clay,	—
4.	Shales and sandstones,	50′
5.	*Lower Kiltanning coal bed*,	3′
6.	Fire-clay,	—
7.	Unexposed interval, probably composed of sandstones and shales, and containing near the center hard, tough, massive calcareous chert, representing the *Ferriferous limestone*,	70′
8.	*Clarion coal bed*,	2′
9.	Fire-clay,	—
10.	JOHNSON RUN SANDSTONE,	40′
11.	*Alton Upper coal bed*,	3′
12.	Fire-clay,	15′±
13.	*Alton Lower coal bed*,	4′
14.	Fire-clay,	—
15.	KINZUA CREEK SANDSTONE,	50′
16.	Black slate and shale, which probably contains a *coal bed* representing the *Marshburg Upper bed*,	10′
17.	OLEAN CONGLOMERATE,	60′
18.	MAUCH CHUNK RED SHALE No. XI, (thickness not determined.)	
	Total,	323′ 6′ ±

* It is impossible to locate the exact position of the bottom of the Olean conglomerate, from the fact that the outcrops were not sufficient to either determine the top of the red shale or the bottom of the conglomerate. A few facts which were observed in this vicinity would rather indicate that the junction of these two rocks is at a higher level.

As will be observed from this section, we have here the representatives of *six coal beds* ; the *Middle* and *Lower Kittanning*, the *Clarion*, the *Alton Upper* and *Lower*, and the *Marshburg* beds, contained within an interval of 250 feet. Several sections have been reported to me as representing the stratification of the *Silver Creek basin*, made by local geologists, which show *five beds of coal* contained within an interval varying from 100 to 200 feet. Surprising differences exist between these sections and that reported here. A diligent search was made for the outcrops and exposures of the beds which appear in the sections made by local authorities. Nothing, however, was found to lead me to suspect that the general section which has been given in this place, would not represent very nearly the stratification at any one point.

Of the *six coal beds* contained in the section, it is safe to assume that there are but four, excluding the *Kittanning Middle* and *Marshburg Upper*, from which coal might be mined. The *Kittanning Lower bed* has been opened and several hundred tons mined by Mr. Schultz. The other three beds, however, have not been developed sufficiently to permit of a final statement as to the character of the coal which they might be expected to produce.

From the fact that all the individual strata, represented in this section, are not exposed one above the other, the thicknesses assigned to them will be found to differ, slightly, from the measurements in any one locality. The territory here is so thickly wooded, and the local detritus is so thick and the exposures so few, that it was practically impossible to determine the exact dip of the strata, without which it was not possible to fix the thickness of the rocks between any two coal beds, at openings at any considerable distance one from another.

At an elevation of 1620 feet, on the slope of the hill facing Bridgetown, black cannelly slate was found outcropping for a distance of from 10 to 15 feet, representing the *Marshburg Upper coal bed.* Immediately above this point, at an elevation of 1675 feet, was found a rock apparently *in situ*, which was taken to represent the KINZUA CREEK SANDSTONE.

Fifteen feet above this point Mr. Schultz opened a coal bed which measured on the outcrop 1 foot 6 inches thick, and was underlaid by fire-clay. This bed was taken to represent one of the *Alton coal beds*, probably the upper of the two which are found in this district.

A short distance beyond this latter point a summit is attained in the road, at an elevation of 1760 feet, which would appear to be high enough to contain a small area of the *Clarion coal bed.* The long level beyond this summit, and between it and where the road crosses Bear creek, is immediately underlaid by the KINZUA CREEK SANDSTONE and the soft argillaceous shales and fire-clays of the *Alton group.* This "level" stretch does not appear to vary more than a few feet in elevation, and the surrounding topographical features would indicate a marked horizontality to the strata.

The elevation of the Bear Creek dry hole, on the left-hand side of the road where it crosses the creek, is 1595 feet. This elevation marks about the top of the OLEAN CONGLOMERATE, although at the well the upper part of this formation has been eroded, and only the lower 25 feet of it was passed through by the well. In the record of the well which was furnished me* this stratum was noted as blue slate. It is with-

*In publishing the records of oil wells, drill holes, and rock sections measured by others and furnished the Survey, the plan pursued has been to give the description of the rock in the same words as reported to the Survey.

In some cases lithological characteristics have been ascribed to the rock, in these descriptions, which it has been ascertained they do not possess. This has been particularly noticed in the records of the oil wells, where a personal interview with those who were engaged in drilling the well would indicate quite a different structure, to special strata, from that which has been claimed by the individual drillers, whose naming of the rocks has been included in the records. From the fact that the same rock is frequently described in different areas by different individuals, little experienced in petrological descriptions, many inconsistencies exist in the records, which a careful study and comparison would enable persons familiar with the territory to clear up. Inconsistent names have not, however, been changed in printing these sections, so that no person need lose confidence in the sections, from the fear that they have been "patched up" in any way. I have frequently come in contact with well drillers who were disposed to call everything a slate rock, which did not bear any direct resemblance to the oil sands. A compact massive sandstone would be described by them as a "*slaty rock*," whereas other drillers, who would be more careful in discriminating between various kinds of strata, would call it a *sand*, *sandrock*, *sandstone*, *or flaggy or slaty sand*, where the larger pieces of rock coming from the well showed the planes of stratification.

out doubt the representative of stratum No. 4 in the Silver Creek well, which is 30 feet thick, and is described in the driller's record-book as pebble sand.

In the road about 200 feet from the Bear Creek well and 10 feet above it, in elevation, a coal outcrop was found, which is without doubt the representative of the *Upper Marshburg bed.* The sandstone occurring above this outcrop is the KINZUA CREEK. The elevation of the summit along the road, about a third of a mile south-west of the well, is 1710 feet. This seems to be immediately underlaid by the JOHNSON RUN SANDSTONE. No indication of the outcrop of a coal bed was found at this point. It is more than probable, however, that the summit is sufficiently high to be underlaid by the *Clermont (Clarion) coal bed*, from the fact that in the Vander mark tract, which is passed through before the Silver Creek well is reached, the *Clermont bed* has been opened at an elevation of 1700 feet. This opening had fallen shut prior to the several visits that I made it; it was reported, however, that the bed was from 2 feet to 2 feet 6 inches thick. Just beyond this locality a bed has been drifted on alongside of the road, which has been locally called "*the Roadside coal.*" The section here is as follows (Fig. 20, page 104):

1. Gray slate and shale, (roof,)	—	
2. Black slate containing streaks of coal,	1′	6″
3. *Coal,*	1′	6″
4. Fire-clay and black slate,		7″
5. *Coal,*		6″
6. Black slate,	1′	6″
7. Fire-clay, (floor,)	—	
Total,	5′	7″

The elevation of the bottom of this bed is 1650± feet, and the bed is the representative of the *Alton Lower coal.* Six hundred feet west of the above opening, and to the left of the road, a coal has been opened, the section of which is as follows (Fig. 21, page 104):

1. Black and gray slate, (roof,)	—	
2. *Coal,*	1′	6″
3. Fire-clay, (floor,)	2′	
4. Gray argillaceous shale,	—	

The elevation of the bottom of this bed is 1670 feet, and it represents the *Alton Upper bed.* The interval between the top of the Silver Creek well,* the elevation of which is 1615 feet, and the coal just referred to, is filled with the upper portion of the KINZUA CREEK SANDSTONE.

On the Elk county geological map the name Bear creek has been improperly assigned to the main head branch of Silver creek. This name belongs to the creek flowing past the first dry hole south-west of Bridgetown, which is known as the Bear Creek well.

On the sheet of sections (Plate No. XI) published in the Atlas accompanying Report R on McKean county a section of the Silver Creek well is given, and above it is added a section of the coal measures in the *Silver Creek basin.* By referring to this section it will be found that but one coal bed is reported in the *Alton group*; this is an error. This section was constructed during my first visit to the *Silver Creek coal basin*, and I failed at that time to understand the structure of the *Alton group.* Except in this particular, the section published on the sheet agrees with that given here.

Beyond the Silver Creek well the hill over which the road passes has been locally named by Mr. Schultz the "S" hill. Although the actual contour of the hill does not in any way resemble the form of the letter S, yet in passing over the hill, on foot, through the woods to the west of the road one might readily appreciate the justice in naming this hill as Mr. Schultz has done, as its shape could easily be imagined to be that of the letter S.

But a short distance to the west of the road, on the southern side of Silver creek, the outcrop of the *Alton Lower bed* has been found in a number of places, by prospectors. At one point, the bed has been opened, and measured but a few feet back from the outcrop 4 feet 4 inches thick, having an argillaceous shale roof and fire clay floor. When this locality was visited late in the fall of 1883, another opening had been made on this *coal bed.* The bed measured 3 feet 6 inches

* More detailed reference is made to the Bear Creek and Silver Creek wells in the introductory chapter.

thick, and was composed of bony, slaty, and cannelly coal. Judging from the character of the coal which had been taken out of this opening, which was driven in but a few feet from the outcrop, the coal did not present a very promising appearance. I was unable to ascertain whether the bed at this point is broken up into benches by included slate strata.

The *Alton Upper bed* was opened by Gen. Kane a short distance above the opening just referred to, and measured 2 feet thick. The elevation of the opening is 1680 feet. This bed bore a striking resemblance to the *Clarion bed* opened on the Vandemark clearing, and has been locally considered to be the same. The opening had fallen shut when I visited it, and the face of the coal could not be seen. The elevation of the opening, however, when compared with those of others in the vicinity, would rather indicate it to be the *Alton Upper bed*, as I have considered it

An opening was made on the *Lower Kittanning bed* by Mr. Nolquist in October, 1874, under the direction of Gen. Kane. The elevation of the bottom of the bed is 1775 feet. When this opening was visited in 1878, the face of the coal had been worked by Mr. Schultz 15 feet back from the outcrop, and measured 3 feet 6 inches thick. In the fall of 1883 this opening was visited again, when the drift had been extended to a distance of probably 125 feet from the outcrop. The bed measured 3 feet thick, and contained no separating slate or bone. Several hundred tons had been taken out and were heaped at the mouth of the drift. The coal resembled very much that from the Bucktail mines, although apparently not containing so much sulphur. The horizon of this bed was located on the road south-west from Silver creek, and seemed to be marked on the outcrop by two separate coal beds 10 feet apart, each 1 foot thick. No prospecting had been done on the outcrop at this point, so that it would not be possible to say whether the bed is actually represented here by two separate coals.

Four hundred feet west of the *Schultz opening*, just referred to, an outcrop was located at an elevation of 1825 feet, the elevation of the summit of the hill above the outcrop

being 1840 feet. This is the representative of the *Kittanning Middle bed.* Nothing is known as to the thickness of this bed, and it would seem to be of very little practical importance, as the area which it would appear to underlie is small, and the amount of roof overlying the bed is thin; even if the bed exists of any considerable size, it would not be under conditions favorable to a good fuel for profitable mining.

Although the *Lower Kittanning*, *Clarion*, and *Alton beds* exist in the *Silver Creek basin*, and any one of them *might* be of workable dimensions and contain desirable coal, it is impossible to judge, from the facts here presented, of the value of this territory for a coal property. The topography is irregular, and no fair estimate can be made as to the area underlaid by any one bed, without a careful topographical survey,* such as the Geological Survey was unable to make.

On both sides of the summit passed over by the road, between the crossing of Silver creek and Little Mill creek, pieces of a hard massive calcareous chert were found at the horizon where the *Ferriferous limestone* might have been expected. This *chert* is, without doubt, the representative of the *limestone.* As far as explorations have been made in the *Silver Creek basin*, no indications have been found of the existence of the *Ferriferous limestone* in a condition in which it might be burned into lime and used as a fertilizer, of which the soil in this section stands so greatly in need.

On the slope of the hill, descending towards Little Mill

*To determine the actual value of a bituminous coal property, for mining purposes, in a region thickly wooded and of irregular contour, such as many areas in Elk county are, it is absolutely necessary that the topographical features should be accurately mapped, in order to permit of the location of the outcrops of the coal beds. The appropriation made by the State for the Geological Survey was not sufficient to permit of close instrumental work of this nature being done, except in special localities, where the geological features were typical of a considerable area, and where the facts obtained, through a minute mapping, would enable the geologist to arrive at conclusions which could be applied to an extended area. Until such a careful topographical survey is made, of the north-western bituminous coal fields in Pennsylvania, where all the coal beds outcrop, nothing can be certainly known as to the actual coal value of many areas.

creek, and to the left of the road, a coal bed has been drifted on, at an elevation of 1710 feet. The bed is 2 feet thick. Between 20 and 25 feet above this opening, another bed has been dug into, which Mr. Schultz reports to be 1 foot 6 inches thick. The former bed is the representative of the *Clarion coal*, and the small bed is without doubt the *Ferriferous coal*, which is so frequently, but irregularly, found underlying the *Ferriferous limestone*.

On the western side of the road, and at an elevation of 1675 feet, was found a block of conglomerate, which had been uncovered by recent rains, when the district was visited in August, 1883, which appeared to be in place; if so, it represents the bottom of the JOHNSON RUN SANDSTONE. In any event it must have come from this upper member of the POTTSVILLE CONGLOMERATE. The elevation of Little Mill creek, where the road crosses it, is 1645 feet.

Ascending the hill from the creek, towards Montmorency, a coal outcrop was found alongside of the road, at an elevation of 1695 feet. The coal smut seen at this point probably came from the *Clarion coal bed*. The elevation of this point is 15 feet below the elevation of the drift on the same coal bed to the north-east of Little Mill creek, which has just been referred to. The elevation of the intersection of the road from Bridgetown with the Warren and Ridgway pike is 1760 feet.

To the east of the road, back of the Schultz barn, the *Lower Kittanning coal bed* has been opened, at an elevation about the same as that of the cross-roads. The section of the bed is as follows (Fig. 22, page 104):

1. Hard gray shale, (roof,)	—	
2. Soft clay shale,	1′	6″
3. *Coal*,	2′	6″
4. Fire-clay, (floor,)	2′	+
Total,	6′	+

The thickness of the rocks overlying the *coal bed* is but a few feet, and a very limited area is underlaid by the bed.

But a short distance beyond the Montmorency barn a rich carbonate of iron is found outcropping in the road. This is without doubt the representative of the *Ferriferous lime-*

stone. It is hardly probable, however, that any ore will ever be found of sufficient quantity, or containing enough metallic iron, to make it profitable to work it, as an iron ore.* Associated with this ore were found pieces of coal, which doubtless came from the *Ferriferous coal bed.* Sufficient prospecting has not been done, to make it possible to report a thickness for either the ore or the coal bed.

A quarter of a mile to the south of the barn, a bed has been opened at an elevation of 1720 feet. A great many balls of rich carbonate of iron were found in the shales immediately above the bed. Although the thickness of the coal could not be determined at this point, I am informed that more or less coal was dug here, a number of years ago, for local consumption.

The elevation of the summit between Little Mill creek and Big Mill creek, about a mile and a half west of Montmorency, is 1820 feet. A coal bed had been opened on the outcrop here in June, 1878, 30 feet below the summit, which is the representative of the *Lower Kittanning bed*, the same bed which has been opened at the *Montmorency coal drift.* The section of the bed, measured at the outcrop, was as follows (Fig. 23, page 104):

1. Black slate, (roof,)	2′	
2. *Coal,*		6
3. Fire-clay,	2′	
4. *Coal,*	1′	
5. Fire-clay, (floor,)	2′+	
Total,	7′	6″+

But a small area is underlaid by the bed.

On the Warren and Ridgway turnpike north-west from Montmorency, the following observations were made: An outcrop was found, at an elevation of 1680 feet, 300 feet south-east of where the road crosses Little Mill creek, for the first time, in the north-west corner of warrant 3284. This outcrop is probably that of the *Clarion bed.* The ele-

*A local tradition exists, which asserts that trees in the Montmorency clearing are more subject to being struck by lightning than anywhere else in this part of the county. If this is a fact, the *Ferriferous limestone* being so heavily charged with iron, at such a slight depth below the surface of the ground here, would seem to suggest a plausible cause.

vation of Little Mill creek, where the road crosses it, is 1665 feet. The elevation of the summit, in the road just beyond this point, is 1765 feet; not quite high enough to contain the *Lower Kittanning coal bed.* The elevation of the second crossing of Little Mill creek is 1685 feet.

Half a mile beyond, a coal outcrop was located at an elevation of 1795 feet, where the bed was measured, and found to be 1 foot 6 inches thick. Sufficient facts could not be had at this point to determine the geological horizon of this outcrop. There would appear to be a rapid dip in the strata to the south-east toward Montmorency; the average rate of dip, from where the road crosses Big Mill creek to Montmorency is, as nearly as could be determined, about 50 feet to the mile.

The elevation of the summit between Little Mill creek and Big Mill creek, along the road, is 1910 feet. This summit would appear to be high enough to be underlaid by the *Lower Kittanning coal bed*, although no outcrop was found at this point. The elevation of the summit to the north-east of this one, and above Mr. Schultz's coal opening, as has already been stated, is 1840 feet. At this latter point the opening on the *Lower Kittanning coal bed* was 65 feet below the summit. The junction with the Ridgway and Warren turnpike, of the road leading into the Eastman place, is 1910 feet. The elevation of the point where the road crosses the Big Mill creek is 1615 feet, and that of the Mill Creek well, on the southern side of the turnpike, and about 400 feet west of the creek, is 1650 feet.

Loose pieces of a flat pebble conglomerate, which bore a close resemblance to the SUB-OLEAN CONGLOMERATE, were found in Mill creek north of the road. No outcrop of the conglomerate was located along the creek, but, as nearly as could be judged from the profile of the hills on either side, the bottom of the SUB-OLEAN CONGLOMERATE is probably not far from 50 to 60 feet above Big Mill creek, where the turnpike crosses it.

The *Fifth anticlinal axis* crosses the pike near the Big Mill creek crossing, probably about a mile to the north-west. The facts which could be obtained for the location of the

axis were rather indefinite, and its precise location is not certainly known.

The exact location of the SUB-OLEAN CONGLOMERATE outcrop in south-western Jones, and the position of the anticlinal axes, are points which have a very important bearing upon the general geological structure of north-western Elk county. A proper understanding of the geology here is of economical importance, not only as affecting the probable coal areas, but more, as affecting the existence of the SUB-CARBONIFEROUS strata under conditions similar to those found in the oil regions, which might influence the probable existence of petroleum. Reference has already been made to this subject in the description of the general structural geology of the county.

The western and north-western parts of Jones township are so thickly wooded, and so few exposures could be found, that its geology cannot be finally understood, without a more extended examination, than that made by the Survey. Sufficient has, however, been determined in this section to conclude, with a good deal of assurance, that few areas will ever be found containing coal beds, other than the *Upper Marshburg* and *Alton coals*, and possibly the *Clarion*.

Although the elevation of the surface along the county road leading from Kane to Highland, and along the Narrow Gauge railroad, varies from 2000 to 2050 feet, (more or less,) the strata have been lifted to such an extent by the *Fifth anticlinal axis* that the higher measures found in the *Silver Creek basin*, at an elevation very much below the surface of the north-western part of the township, originally occurred here at such a height that they have now been eroded.

One of the most striking geological and topographical features in the *Johnson Run basin* is the bold outcrop of the top member of the POTTSVILLE CONGLOMERATE No. XII, which is called the JOHNSON RUN SANDSTONE, from the fact of its being more boldly developed in this basin than anywhere else. The *Clarion bed* frequently immediately overlies it, being separated from it only by its under-clay. The *Alton Upper bed* immediately underlies it. The roof of this

coal is sometimes formed of one of the massive strata of the JOHNSON RUN ROCK, and sometimes by slate or shale of a few feet in thickness, which separates the coal from the sandstone layers of the JOHNSON RUN interval. The strata of this interval are composed of a rather massive fine-grained ferruginous sandstone, alternating with shale and slate. The sandstone is frequently conglomeritic, but the pebbles are small and scattered. The grains of sand are more glistening than those contained in either the KINZUA CREEK SANDSTONE or OLEAN CONGLOMERATE, and the cement which holds them together is less calcareous than those of the latter rocks. The iron contained is mostly disseminated throughout the body of the rock.

In certain localities, special sandstone strata appear to be more ferruginous than others. This feature is quite marked on the Kane summit, where the more ferruginous portions of the rock have an even pink color. This fact, and the homogeneity of the rock, render it a desirable building stone in these places. Most of the sandstone contained in the walls of the Presbyterian church at Kane has been obtained from loose blocks of the JOHNSON RUN SANDSTONE found in the vicinity. From the fact that the rock is more compact and massive than the two underlying members of the CONGLOMERATE No. XII, it does not break up under the influence of the weather as rapidly, so that the rock cities, formed by it, are more frequent than those formed either by the KINZUA CREEK or OLEAN.

The iron contained in the sandstone has a tendency to segregate in irregular masses through the body of the rock, which masses somewhat resemble ordinary mineral veins. These more ferruginous portions, near exposed surfaces of the sandstone, seem to be less attacked by the weather, so that ridges or irregular-shaped protruding masses of the rock, containing the most iron, are not infrequently found covering the faces of the sandstone, particularly the vertical ones. The protruding masses sometimes have such irregular outlines, and are so prominent, that imaginative persons readily interpret them into distinct forms, in the same way that marked resemblances are traced between familiar ob-

jects and the irregular forms of stalactitic calcite found in limestone caves. To most persons the most striking resemblance exists between these protruding masses and hogs' ears. All of these features clearly characterize the masses of this sandstone found in the *Johnson Run basin.*

The boldest outcrops of the rock in this basin are found along the slopes on either side of the East Clarion creek. Those which are especially familiar to residents are on the north-western side of the creek, near the headwaters of Swamp and Burlingame runs. Rock cities are formed here which are among the most interesting, as far as beauty is concerned, of those seen anywhere in north-western Pennsylvania.

The popular explanation, which is generally given to account for these bold sandstone and conglomerate outcrops, that the rocks have been upheaved, has been employed to explain the occurrence of rock cities in this district. Although there is nothing peculiar or novel in these rock cities to the geologist, yet a word of explanation as to their formation may not be uninteresting to those persons who so frequently make the localities where they occur the scene of festivity during the summer picnic season.

This sandstone is only one of a series of strata which lie very nearly horizontal, as far as I could detect, in many places. The eroding agents, which attacked and broke them up piecemeal, have an unequal effect upon different rocks. Those which are easily attacked and broken up by atmospheric influences are eroded rapidly, and bold outcrops are seldom seen, while those which resist the attacks of the atmosphere, and are included between softer strata have, as a rule, bold outcrops. Such is the case with the JOHNSON RUN SANDSTONE. The shales underlying the *Clarion bed*, and the shales, slates, and fire-clays overlying the *Upper Alton bed*, are rapidly eroded, leaving a cliff of the JOHNSON RUN SANDSTONE exposed between them. The underlying strata composing the *Alton group* are sometimes cut away so rapidly that the sandstone is undermined. When this is done, to such an extent that the overhanging portion of the sandstone becomes too

heavy to be retained in this position, blocks are broken off and tumbled down the slope beneath them. When this does not occur, blocks of the sandstone are broken from the main body of the rock by water entering into the smaller cracks and crevices, which afterwards freezes. The expansion which takes place in the freezing of water into ice is so powerful, that it wedges blocks from the main body of the rock. The argillaceous character of the strata underlying the JOHNSON RUN ROCK forms a slippery bed, upon which the rocks are moved. In the case of the Johnson Run rock cities, this is a condition especially favorable to their formation. The amount of this wedging, during a single winter, may be almost inappreciable, but continued freezing and thawing, during a long period of years, will ultimately push blocks of enormous size several feet apart.

Upon a close study and measurement of many of these blocks, it will be found, that the faces on either side of a crevice are the same distance apart, and that one face is exactly the opposite of the other face; although both rock faces may be irregular in shape, yet, if one block was pushed back into its original position, the projections on its face would fit the depressions in the face of the adjoining rock.

The rocks at these rock cities in north-western Pennsylvania are not upheaved, as is popularly understood, nor does a study of the facts to be obtained from a close examination of the rocks give evidence that the rocks have been subjected to an earthquake action.

In the section of the coal measures given for the *Johnson Run basin* (see page 69) an average thickness of 75 feet is assigned to this sandstone. From a number of measurements, not altogether satisfactory, made in this basin, the interval between the *Alton Upper bed* and the *Clarion bed* probably approaches more nearly 80 feet. The face of the sandstone at the different rock cities varies in height from 30 to 75 feet. Great local variations exist in the thickness of the sandstone in the *Johnson Run basin.*

The JOHNSON RUN SANDSTONE interval thins from 70 feet, near the headwaters of Swamp and Burlingame runs, down to 26 feet, on the Field tract north of Straight creek.

Chapter VIII.

Ridgway Township.

Ridgway lies east of Highland and Spring creek, south of Jones, west of Benzinger and Fox, and north of Fox and Horton.

All the streams which drain its surface flow into the Clarion River within the limits of the township, except a few small branches of Bear creek, which empties into the Clarion at Portland in Spring Creek township, about one mile west of the line which separates this township from Ridgway. The two principal arms of the Clarion River,* the East and West branches, unite in the north-eastern part of the township at Johnsonburg. Below the junction the course of the river is very sinuous. From Johnsonburg it flows nearly due south for about two and a half miles, when it makes an abrupt turn to the west; from this point the general direction of its course is south-west to a point 5 miles (air line) below Ridgway, where it turns sharply to the north of west just before it enters Spring Creek township.

The course of the Clarion in Ridgway is so very irregular that at first sight there seems to be no law governing its direction. A careful study of the geological map of Elk county (Plate II), however, will reveal the fact that the geological structure has determined the position of its bed. From Bridgetown, which is located in the center of the *Johnson Run basin*, to a point immediately south of Powers' run, the dip of the strata is very regular, but in an opposite direction to the flow of the river. Between the mouth of Powers' run and the right angle bend one and a half miles south of it, the dip of the rocks rapidly increases, and

* The name river, I believe, should be limited to the Clarion below the junction, although on some of the old maps both the East and West Branch creeks are frequently designated as rivers.

at the same time the strike, which before was nearly due north-east and south-west, assumes a more westerly direction.

The change of dip offers a greater resistance to the flow of the stream, and the change of strike deflects the line of least resistance to the west, the result being that the course of the Clarion becomes west, instead of south as before. From this bend the general course is south-west for about eight and a half miles (air line), and parallel to the strike of the rocks, although at no time does it absolutely flow along the strike for more than a few hundred feet, there being twelve or more right angles in its course, which, for short distances, assumes almost every possible direction of the compass. This sinuosity results, no doubt, from the slight fall in the stream and the very horizontal position of the strata through which it has cut its way. This fall is not sufficient to occasion a straight course, such as frequently results when a rapidly falling stream has cut its channel out of flat rocks, nor is the dip of the strata of that degree to determine a comparatively continuous course in one direction.

A third fact, which must not be lost sight of, as an aid in determining the location of the Clarion River bed in the lower part of Ridgway, has been the frequent alternation of of the POCONO STRATA, out of which the present bed has been cut. Some of the strata are harder, more compact, more argillaceous or siliceous, than others, and offer a varying resistance to the principal eroding agents, air and water. The stream would naturally continue to flow in a constant direction, until deflected by one or the other of the three determining facts, when its course would be changed. The fact that the Clarion does not continue in a general south-west course, after leaving Ridgway, cannot be argued against the explanation of its features in this township, which I have given. The dip and strike of the rocks, which are found to maintain in Ridgway, do not continue into southern Spring Creek, so that we would naturally expect the general course of the stream to change.

The principal streams on the east side, commencing at the

north, are the East Clarion branch, Powers' run, and Elk creek; and on the west side, Silver, Little Mill, and Big Mill creeks.

A notable feature, which may be remarked, is the parallelism of the course of the Clarion River north of the right angle bend east of Whistletown, the West Clarion to Wilcox, the Five Mile branch north of Wilcox, the Little Mill creek, the Big Mill creek, and Bear creek. The general direction of the flow of these streams is due south, running up and down the dip of the rocks without any apparent change in the direction. This feature is prominently defined on the geological map, where the light color assigned to the POCONO FORMATION accents it. That this is the result of chance, seems highly improbable, and yet, from a close study of this feature, I have not been enabled to ascertain what geological features could have influenced the flow of these streams, to make the valleys which they have eroded more or less parallel. I have long been of the opinion that the rocks of north-western Pennsylvania are more or less jointed, and that these joints have resulted from a contraction of the crust during the process of secular cooling, and it may be that a series of joints, if parallel, has been the determining cause in influencing the flow of these streams.

The topography of the township for some distance back of the river is in general characteristic of that in the immediate vicinity of the Clarion and its principal branches, east and west, throughout the county. Along these streams the prominent features which strike the eye are the scolloped ridges or knolls, having apparently nearly the same height when viewed from the valleys; it will be found, however, that their summits range between 300 and 600 feet above the bottoms of the valleys; the lowest summits being generally nearer the center of the *Johnson Run basin*, and the highest summits nearer the anticlinals. This results from the fact that most of the hills are capped, either by one of the members of the POTTSVILLE CONGLOMERATE, generally the OLEAN or KINZUA CREEK SANDSTONE, or one of the harder strata in the upper part of the POCONO, No. X.

The steepest slopes are generally found near the base of

the hills, on account of the character of the POCONO STRATA which underlie them, and which are more easily eroded than the sandstone. This, however, is not so prominent a feature as in Cameron county, where the differences in the susceptibility of the two classes of rocks to the action of the eroding agents are greater than in central Elk. The POCONO STRATA become more flaggy and slaty and of a more argillaceous character, toward the east.

Back from the streams the topography is not unlike that in Jones, Highland, and Spring Creek. The summits are flat, and when one is buried in the forests which cover them, it might be inferred that the surface was an immense plateau, although within a distance of one or two miles of any point, the surface rapidly pitches into one of the valleys which surround these small elevated plateau areas.

The greatest elevation measured in the township was 2166 feet, that at the Boot Jack cross-roads, in the south-eastern corner, on the road between Ridway and Centerville. The point of lowest elevation in the township is where the Clarion River crosses its western line near the mouth of the Little Toby creek, 1321± feet. This is apparent to any one inspecting the map, as it is the lowest drainage point.

Almost the entire township lies within the limits of the *Johnson Run (Fifth) bituminous coal basin.* A small area in the south-eastern part lies over the *Fourth anticlinal axis*, and a still smaller area on the eastern slope of this anticlinal may be said to lie within the *Fourth bituminous basin.*

The axis of the *Fifth basin* traverses the north-western corner of the township in a nearly due north-east and south-west direction. Its position is more prominently located by the cross-roads at Montmorency, which nearly overlie it, than by any other point in its course. It crosses the P. & E. R. R. about half a mile south of Bridgetown, and about midway between Bridgetown and the northern line of the township. Although there is nothing to be especially remarked in the structure of this basin, it is found to possess a peculiarity which seems to be common to all of the main basins in the district, and that is in being dimpled along its

axis. In this case that portion of the *Fifth basin* which is known by the name of *Silver Creek*, in the northern part of Ridgway and southern part of Jones township, forms one dimple, while the *Johnson Run basin* forms the second dimple, with a slight dome between them. This dome, although a very low one, is indicated by a close study of the dips. The valley of the West Clarion creek forms a bold topographical break between these two prominent coal basins.

The *Fourth anticlinal axis* enters the township from Horton, bisecting the line separating the two townships. The general course of this axis is nearly parallel to that of the *Fifth basin* further to the north-west. It would seem, however, to bend slightly to the east as it approaches the valley of the Elk creek, in the vicinity of Daguscahonda station on the P. & E. R. R. At this point the axis is suddenly deflected to the west, and enters Benzinger about the center of the line separating that township from Ridgway. The difficulty of defining the exact position of this axis is great, and its general position south-west and north-east of this decided change in its direction, is shown on the geological map of Elk county (Plate II). Where this sudden bend occurs, in its direction, the coal measures sink low enough to be included beneath the present hill tops, although it is doubtful whether any coal beds exist at this point, which could be profitably mined. This coal area has been locally named the *Scahonda coal tract or basin*, and is referred to more particularly in the report on Benzinger township.

A more valuable coal area is included within the *Silver Creek coal basin*, but, from the fact that the larger portion of this basin lies in Jones township, more special reference has been made to its geology in the report on Jones.

Although the coal areas, and in fact the formations containing any profitable mineral, in Ridgway are very limited, as compared with the townships immediately surrounding it, with the exception of those on the west, yet to the geologist, this is one of the most interesting areas in the county, and the facts which have been obtained in it, bearing not

only upon the local geology, but upon the general structure of the area surrounding it for many miles, are probably more important than those obtained in any other township in the county.

The lowest geological stratum is probably that found at water level in the vicinity of Ridgway, which is of POCONO AGE and occurs immediately under the SUB-OLEAN CONGLOMERATE. The highest stratum is found in the *Silver Creek basin*, along the northern line of the township.

Our knowledge of the stratification is further supplemented by the important and carefully kept records of the several wells which have been drilled in search of oil, but which have proved dry. The most important of these are the Silver Creek well drilled near the northern line of the township, the Johnsonburg well, the old Dickinson well at Ridgway, and the more recent borings which have been made by the Ridgway Gas Company, the record of whose well has been carefully kept through the solicitation of Hon. C. R. Earley, and which has been reported to me, and published in the chapter on structural geology.

These well records give us a pretty thorough insight into the character of the strata which underlie the township, beneath the lowest rocks exposed at water level near Ridgway. From the fact that these dry holes have been drilled at various times, with a number of years intervening, by different parties, who employed different drillers, I regard the information which they furnish as the most reliable of any in this section.

The total thickness of known strata in the township in the vicinity of Ridgway and the old Dickinson well is 710 feet, sub-grouped as follows:

COAL MEASURES, (including the CONGLOMERATE No. XII,)	285′
MAUCH CHUNK, No. XI, POCONO, No. X,	325′
RED CATSKILL, No. IX,	100′±
Total,	710′

Of this total thickness about 400 feet are exposed above water level.

The general section of the coal measures in the *Silver Creek basin* may be said to illustrate very fully the char-

Fig. 24. p. 127.
Silver Creek Basin, north of Montmorency.
see Fig. 19. p. 104.

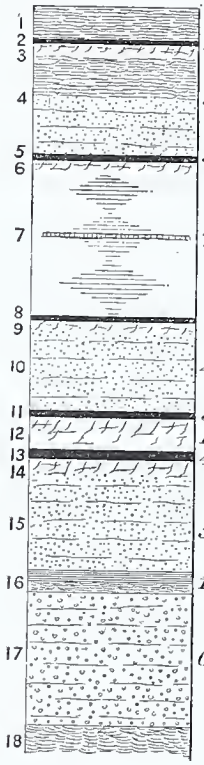


Fig. 25. p. 132.
Section from summit of Ridgway Hill, to top of Dickinson Well on Ridgway Flats.

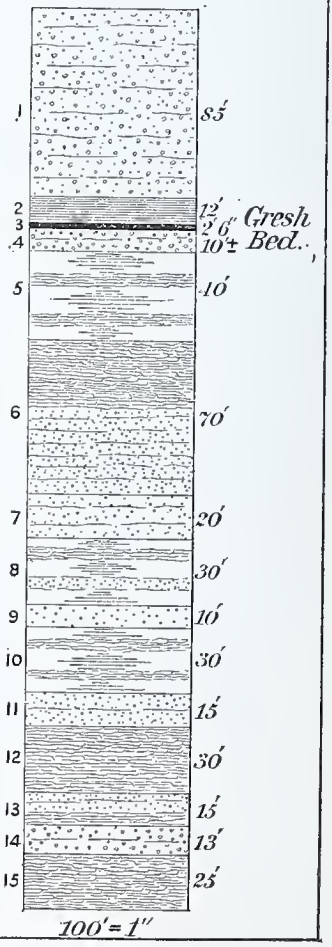
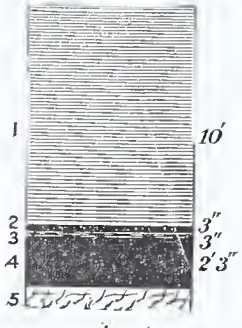


Fig. 26. p. 132.
Gresh Coal Bed Ridgway Hill.



acter of this formation throughout the township. The section is as follows (Fig. 24, page 126):

1.	Shales,	15′
2.	*Middle Kittanning coal bed,*	1′ 6″
3.	Fire-clay,	—
4.	Shales and sandstone,	50′
5.	*Lower Kittanning coal bed,*	3′
6.	Fire clay,	—
7.	Unexposed interval, probably composed of sandstones and shales, and containing, near the center, hard, tough, massive calcareous chert, representing the *Ferriferous limestone,*	70′
8.	*Clarion coal bed,*	2′
9.	Fire-clay,	—
10.	JOHNSON RUN SANDSTONE,	40′
11.	*Alton Upper coal bed,*	3′
12.	Fire-clay,	15′±
13.	*Alton Lower coal bed,*	4′
14.	Fire-clay,	—
15.	KINZUA CREEK SANDSTONE,	50′
16.	Black slate and shale, which probably contain a coal bed representing the *Marshburg Upper bed,*	10′
17.	OLEAN CONGLOMERATE,	60′
18.	MAUCH CHUNK RED SHALE No. XI, (thickness not determined,)	—
	Total,	323′ 6″

With the exception of several small areas in the northern part, none of the coal strata above the JOHNSON RUN SANDSTONE are found to exist anywhere in the township.*

The summits along the eastern line of the township north of Scahonda are capped by the JOHNSON RUN SANDSTONE, so that no coal beds might be expected to be found here except those of the *Alton group* and the *Marshburg beds*, upon which, however, no dependence can be placed, for practical mining. This particularly applies to the latter beds.

*On the geological map of Elk county two areas are indicated, near the center of the west line of the township, as underlaid by the *Ferriferous limestone* or its representative, which is probably poor bastard rock. No coal beds have been opened, as far as known, in this section and the areas which are shown on the map have been outlined, not from actual observations, upon what could be definitely stated to be the representative of either the *Ferriferous limestone* or any of the underlying coal beds, but from a study of the topographical profiles, in conjunction with the general structure of the *Johnson Run basin* at this point; from which might be inferred the existence of the coal measure strata indicated by the map. Extensive prospecting would have to be done, before anything could be finally stated as to the probable value of any of the tracts here, for mining purposes.

In the vicinity of Boot Jack (cross-roads) in the south-eastern corner of the township, the summits, which are broad and of very slightly varying heights, are successively capped by the sandstone members of the POTTSVILLE CONGLOMERATE group; the portion of the summits nearest Ridgway being capped by the OLEAN CONGLOMERATE, and those further to the south-east, nearer to Boot Jack, by the JOHNSON RUN SANDSTONE.

The structure of the *Fourth anticlinal* is clearly defined by the exposures along the P. & E. R. R., between Ridgway and St. Mary's. Careful observations were made of these exposures, in going from Ridgway to St. Mary's, and are recorded in the following notes. The elevations were deduced from barometric determinations, but as very little opportunity was afforded for checking or correcting these elevations, when the section was run, they are only approximate; although they may be found to differ, very considerably, from the elevations on the railroad profile, they are sufficiently close to aid in a proper understanding of the geological structure.

Running section along P. & E. R. R., between Ridgway and St. Mary's.

Bar. elevation.	DESCRIPTION.	LOCALITY.
	Olive gray shale and occasional seams of sandstone. Dip* 1° S. 79° W.	West of railroad station at Ridgway.
1485′	Bottom of strata exposed forming the steep slopes of hills.	Above saw-mill, East Ridgway.
1402′	Soft micaceous greenish gray and olive sand-shale, alternating with thin beds of conglomeritic sandstone. Dip 1° N. 67° W.	Two and a half miles east of Ridgway, and about a quarter of a mile east of bridge No. 69.
	Olive and gray shale and sandstone, 15 feet exposed above the railroad tract.	Mile post No. 121.

*The dips recorded in this section are the dips observed at the exposures and cannot be taken to represent the average dip of the strata for any distance.

Bar. elevation.	Description.	Locality.
1425′	Fine green and gray sandstone, alternating with shales, exposed for 12 feet above railroad tract. At the bottom of the exposure, on a level with the railroad, the sandstone is highly ferruginous, and contains fragments of Spirifer disjuncta and other Chemung forms which it was impossible to distinguish. At one point of the exposure there is a decided dip for some distance, of 2° to the south-east. Judging, however, from the general view of the exposure, the rocks are nearly horizontal.	Three miles east of Ridgway.
	Alternating shales and sandstones.	Four miles east of Ridgway.
1436′	Top of well drilled by Col. J. S. Bates. The well was discharging during July, 1876, gas and water, the latter being strongly impregnated with salt, iron, and sulphur.	Half a mile west of Daguscahonda.
	Gray shale.	Daguscahonda.
1500′	Greenish gray and olive sand-shale, very much stained with iron, alternating with flaggy sandstones of varying hardness. The softer layers are quite fissile. Dip 1 foot in 200 feet; direction north-west.	Long cut six and two-thirds miles east of Ridgway
1520′	Gray shale.	A quarter of a mile east of Scahonda station.
1520′	Greenish gray and olive shale, alternating with soft flaggy sandstones. The surface of some of the strata here are stained red and yellow by iron, and on this account some of the rocks might be mistaken for red shale. Some of the sandstone layers have a vertical cleavage and concretionary structure. Height of the exposure, 15 feet. Very slight dip to the east.	Two-thirds of a mile east of Scahonda station.
1550′	Fine-grained, light-green, micaceous sandstone, with olive-gray shale, very much stained with iron. Height of exposure, 15 feet. Dip 2° S. 75° E.	Eight and a quarter miles east of Ridgway.
1553′	Red shale.	Eight and a quarter miles east of Ridgway.
1563′	Alternating olive and red shales, the former predominating.	Eight and a quarter miles east of Ridgway.

Bar. elevation.	Description.	Locality.
1576′	Olive and green shale and sandstone, the former predominating. The sandstone is boldly false-bedded. The height of the exposure is 10 feet. Dip 2° S. E.	Four hundred and eighty feet west of Silver creek bridge, 8 and two-thirds miles east of Ridgway.
1603′	Massive gray and greenish-gray fine-grained micaceous sandstone. Height of exposure, 42 feet.	Sandstone quarry east of Silver creek, 9 miles east of Ridgway.
1632′	Greenish-gray soft fine-grained micaceous sandstone.	Directly east of the former point.

All the rocks found exposed in this section belong to the Upper Pocono No. X formation. The dips of the strata show that a flat broad anticlinal crosses the P. & E. R. R. directly east of Daguscahonda. From the axis of the anticlinal to a short distance west of Daguscahonda, the dip toward the north-west is so slight, that it is hardly appreciable in the rock exposures. From this point, however, to Ridgway, for a distance of about 5 miles, the average dip of the rocks is about 1° in a direction N. 67° to 75° W. The dip slightly increases towards Ridgway.

From Ridgway to the crest of the above anticlinal the strata are well exposed in the railroad cuts, and consist principally of olive and greenish gray sandstones, both being quite soft and easily broken up on exposure to the weather. The shales in a number of exposures become very loose, and have a fissile structure. All of the strata are more or less micaceous, and their surfaces are very much stained by iron, which gives them a red and yellow hue. To the casual observer, the impression is conveyed that the strata are red, but, if the exposed surfaces are broken off, the color of the interior is found to be generally gray or olive. The north-western dip of the strata being slightly greater than the grade of the railroad from Daguscahonda toward Ridgway, the strata which outcrop above water level at the former locality will be found below water level at the latter.

East of the crest of the anticlinal, for 2 miles, the dip of the strata is nearly 2° in a direction S. 67° to 75° E. toward Silver creek, where the dip becomes very much less, as the center of the *St. Mary's coal basin* is approached.

The facts obtained in running the section along the railroad, combined with those observed on the *Scahonda coal tract*, and along Powers' run, between the Clarion and the point where the St. Mary's-Smethport pike crosses the run, have been quite sufficient to show a sudden turn in the general direction of the *Fourth anticlinal axis*.

The strata above water level at Ridgway are fairly exposed, to the top of the round hill to the north-east, and included within the bold curving of the railroad, which is observed on the map. Although no continuous line of exposures is found at any one point, yet the series of observations, made along the several profiles of the hill, have permitted the construction of a section, with but few intervals concealed.

The first section of the Ridgway hill was constructed in July, 1878, and is published on the sheet of sections (Plate XI) contained in the atlas accompanying Report R, (on the geology of McKean county.) Subsequent observations made, both conjointly and independently, by Mr. Sheafer and myself, permitted of the filling out of some of the concealed intervals noted in the section referred to. This revised section has been published on one of the sheets of sections (Plate VI) accompanying this report. Still further observations made by Mr. Carll, the record of which he has placed in my hands, and additional ones made by myself in the fall of 1883, would suggest a still further modification* of the structure, which is shown in the section below.

* The differences which exist in these sections are no evidence in proof of the impossibility of geologists determining the character of the rocks underlaying any given area; but, instead, commend the work of each geologist in this locality, and show the necessity for a more detailed and extended examination of the stratification, in many localities, than it has been possible for the Survey to make. For general practical purposes, the section, as it is published on the plate accompanying Report R, is quite sufficiently complete. The later facts which have been obtained have, however, added much to our knowledge of the structure, and have given additional information, which serves to confirm the views which have always been maintained, by myself, as to the stratigraphy of the UPPER DEVONIAN and SUB-CARBONIFEROUS ROCKS in the district.

The section of the Ridgway hill is as follows (Fig. 25, page 126):

Elevation on summit of hill, 1795′.

1.	Sandstone and conglomerate,	85′
2.	Black slate,	12′
3.	*Gresh coal bed*,	2′ 6″
4.	Conglomerate,	10′±
5.	Concealed, probably composed of gray and red shales,	40′±
6.	Shales and shaly sandstone,	70′
7.	Yellow and gray sandstone, foliated,	20′
8.	Partly concealed, probably shales and shaly sandstone,	30′
9.	Coarse-grained massive sandstone,	10′
10.	Partly concealed, probably gray shales,	30′
11.	Massive fine-grained sandstone,	15′
12.	Shales,	30′
13.	Sandstone and shale,	15′
14.	Flat pebble conglomerate, (SUB-OLEAN,)	13′
15.	Olive and gray shales stained with iron, down to 4′ above level of top of Dickinson well,	25′
	Total,	407′ 6″

The elevation of the top of the Dickinson dry hole is 1383 feet, 10 feet below P. & E. R. R. station.

The coal bed noted near the top of the section was first opened in January, 1879, and 50 tons were mined. The section of the bed, measured in the summer of the same year, is as follows (Fig. 26, page 126:)

1.	Black slate, (roof,)	10′
2.	*Cannelly coal*,	3″
3.	*Bony coal*,	3″
4.	*Coal*,	2′ 3″
5.	Fire-clay, (floor,)	—
	Total,	12′ 9″

This coal opening was made on Mr. Hyde's land, under the direction of Mr. E. K. Gresh, of Ridgway, who controlled the opening when it was visited in 1879. In the Ridgway section the black slate overlying the bed is noted as 12 feet thick; 10 feet of this was actually tested, and I was informed by the miner, who had taken the slate down,

Attention is called to this fact here, because Mr. Chance, from his survey of Clinton county, and of the Susquehanna valley from Lock Haven to the West Creek summit and westward to Ridgway, has suggested a solution of the structure quite different from that held by myself. No comparison is suggested in this report between Mr. Chance's survey, and that made by Mr. Shcafer and myself; and for an examination of his facts and conclusions the reader is referred to the report on Clinton county, (Report G[4])

that there were indications of its being 20 feet in thickness. I obtained no facts which led me to suppose that it was greater than 12 feet thick. At one point, 6 feet above the bed, a small rider of coal was found, which was 3 inches thick, and at another point, 12 feet above the bed, 3 inches, of what seemed to be fire-clay, slate and coal mixed together were found. Twenty feet below the *Gresh bed* 6 inches of coal was found, the upper part being cannel coal and the lower part bituminous coal. Sandstone, with a little slate, occurred between the *Gresh bed* and this latter coal.

It was reported that a small bed of kidney ore had been found about 60 feet below the *Gresh bed*. Of this, however, I saw no indications during the several visits made to the opening.

From a comparison of the section obtained here with others in the district, I was at first disposed to regard this bed as the representative of the *Marshburg Lower coal*, whose position at Marshburg, in Lafayette township, McKean county, where the bed was opened and was named from its locality, was directly underneath the OLEAN CONGLOMERATE. Mr. Carll has made a careful examination of the Ridgway hill, and believes the bed to be the representative of the *Marshburg Upper coal*, which occurs between the OLEAN CONGLOMERATE and the KINZUA CREEK SANDSTONE.

Mr. Carll in his section reports an interval of 20 feet, directly underneath the coal, as concealed, and below this a coarse sandstone containing pebbles, which he notes as 25 feet thick, and which he is disposed to consider the lower part of the OLEAN CONGLOMERATE. Mr. Carll's view, although different from my own in this respect, is worthy of the highest consideration, and if the section immediately underneath the bed could be exposed, his judgment might prove correct.

After Mr. Carll made known to me the results of his examination, I visited the locality again, but from all the rather indefinite facts which I could obtain, there was nothing which would lead me to conclude that more than 10 feet of conglomerate, which is indicated in the Ridgway section just given, would be found underlying the coal bed.

While there are some facts which would seem to support the one view that this bed is the representative of the *Upper Marshburg*, and some to support the other view that it is the representative of the *Lower Marshburg coal*, all the information, which it is possible to obtain at present, is of too indefinite a character, to make a final statement as to the true horizon of the *Gresh coal bed.*

While it may be possible that this bed is underlaid entirely by the OLEAN CONGLOMERATE, my view, which was first expressed, that the OLEAN CONGLOMERATE occurred above the coal, I do not feel at present disposed to abandon. The fact is, that when a bed is found underlying the OLEAN CONGLOMERATE, there is, as a rule, no bed of conglomerate underneath it, yet, when the dynamical conditions under which our conglomerate of the coal measures was deposited, are considered, it would seem quite possible that a sporadic bed of conglomerate might occur locally beneath the coal bed. While I obtained no facts to lead me to suppose that the 25 feet of conglomerate, indicated by Mr. Carll as occurring 20 feet underneath the coal bed, actually exists, the facts which I obtained are not sufficiently definite to prove that it does not exist.

On the sheet of sections (Plate VI) the interval of 45 feet directly below the conglomerate, underneath the coal bed, is represented as being composed of red shale of the MAUCH CHUNK No. XI formation. This interval in the Ridgway hill probably contains but very little red shale, since no outcrop of it was seen. Red soil and outcropping red shale were, however, found at several places on the surrounding hills, and, as nearly as can be estimated, the red and gray shales which represent this formation are from 45 feet to 50 feet thick, in this portion of Ridgway township.

The conglomerate (stratum No. 14) near the base of the section, which is 13 feet thick, outcrops near the base of the hill, to the west of the P. & E. R. R. station. This conglomerate is the representative of the SUB-OLEAN CONGLOMERATE. Its discovery and identification at this point has a very important bearing upon the structural geology of central Elk. Reference has already been made to this in the description of the SUB-OLEAN.

Wilmarth coal tract.

On the ridge between the Clarion River and the Little Mill creek, south-west of Wilmarth, a coal bed has been opened and considerable coal mined and shipped to market. The area which contains the coal bed, which lies in warrants 3285 and 4850, has been known as the Wilmarth* coal tract, and the name which has been more recently applied to the colliery has been the Glen Mayo, which was operated by Mr. J. H. Mayo. The views which have been held by local geologists, as to the identity of this bed and the value of this tract for mining purposes, have been various; so that, the determination of the true position in the coal measures of the bed that has been worked here is of the greatest practical importance, not only to convey to those who may reopen this colliery, in the future, a correct idea as to its possibilities, but to prevent an over-estimating of the value of the tract, by those who have been sanguine as to the number of coal beds which underlay its surface.

The elevation of the Wilmarth station is 1447 feet. About a quarter of a mile south of the coal tipple, at the foot of the old plane, loose scattered blocks of a coarse-grained highly ferruginous conglomerate were found. These blocks appear to be but a few feet below their true position; and underneath what would seem to be the stratum from which they came, was seen an outcrop of fire-clay, at an elevation of 1810 feet. All the indications would lead to the conclusion, that this fire-clay marks the bottom of the OLEAN CONGLOMERATE. The elevation of the coal bed at the mine is 1908 feet. There is but little doubt that the coal bed opened on the Wilmarth tract is the representative of the *Alton Lower*, and that it occurs immediately on top of the KINZUA CREEK SANDSTONE; so that, the combined thickness of this sandstone and the OLEAN CONGLOMERATE, and the slates and coal bed included between them, representing the *Marshburg Upper bed*, is 100 feet. The section of

*I am informed that the Wilmarth mine was originally opened by Mr. Frank Whitney, a detective connected with the Chicago police force, and Mr. John Van Dangen, conductor on the P. & E. R. R.

136 R R.

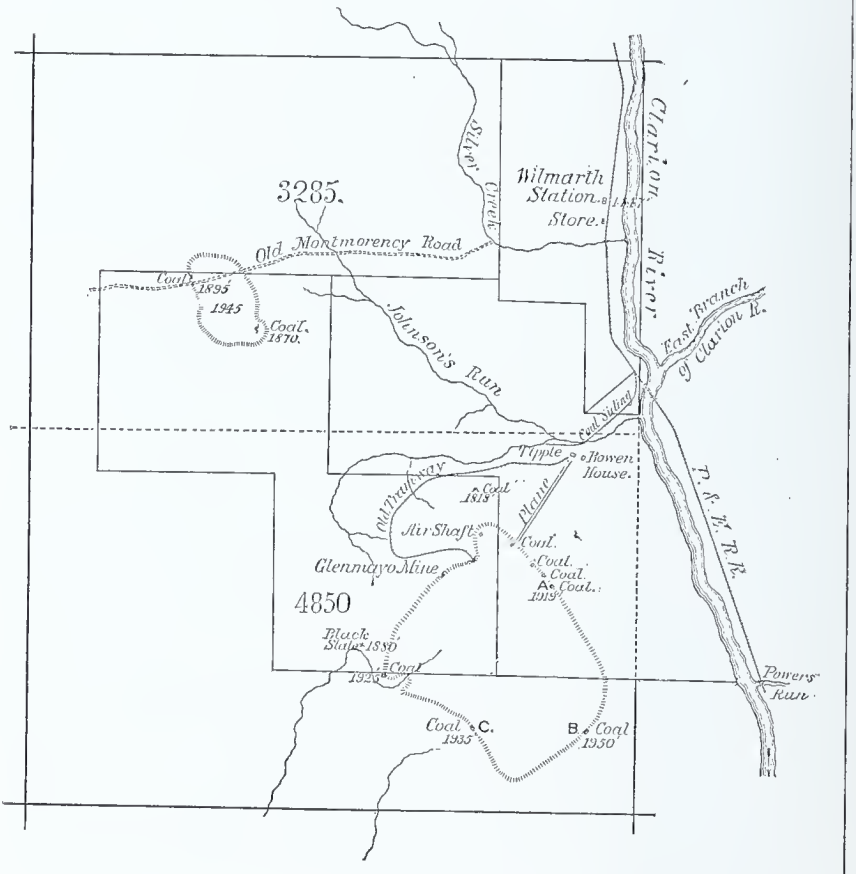
Map of the Wilmarth Coal Tract

showing the

Areas underlaid by the Alton Lower Bed.

Reduced from original drawing of

J. H. Mayo, Mining Engineer.



O.B.H.

the bed at the mine, measured in July, 1878, not far from its mouth, was as follows (Fig. 27, page 138):

1.	Gray argillaceous slate and fire-clay, (roof,)	—	
2.	*Coal*,		10″.5
3.	Slate,		3″
4.	*Coal*,		6″
5.	Slate,		2″
6.	*Coal*,		8″
7.	Slate,		2″
8.	*Coal*,	1′	4″
9.	Fire-clay, (floor,)		6″
10.	Hard sandstone,	1′+	
	Total,	5′	5″.5+

The course of the drift from the mouth is nearly due south-east, and it rises at the rate of 6 feet in 400 feet. The coal bed in this distance maintains a constant section. The condition of the coal bed in this distance, however, is no criterion of its character, throughout the extent of the property. This is borne out by the section of the bed given below. A section, measured near the face of the mine in September, 1879, was as follows (Fig. 28, page 138):

1.	Gray argillaceous slate and fire-clay, (roof,)	—	
2.	*Coal*, with variable slate binders,	1′	8″
3.	Slate containing iron pyrites,		3″
4.	*Coal*,		10″
5.	Slate,		2″
6.	*Coal*,	1′	6″
7.	Hard sandstone, (floor,)	—	
	Total,	4′	5″

This latter section is quite different from the one nearer the mouth of the mine, and shows the disposition of the bed to change very much in its constitution. The pyritiferous slate immediately below the top bench, in the vicinity of where this section was measured, is sometimes 4 inches thick, and at other times is absent altogether. The slate under the second bench of coal varies in thickness from 1 to 3 inches, while the bottom coal bench is sometimes as low as 8 inches and as great as 1 foot 8 inches in thickness; the average for several hundred feet, in the vicinity of where the section was measured, would probably not be far from 1 foot 2 inches. The sandstone which immediately

Fig. 31. p. 140.
Upper & Lower Alton Beds.

Air Shaft.

Sections on Wilmarth Coal Tract.

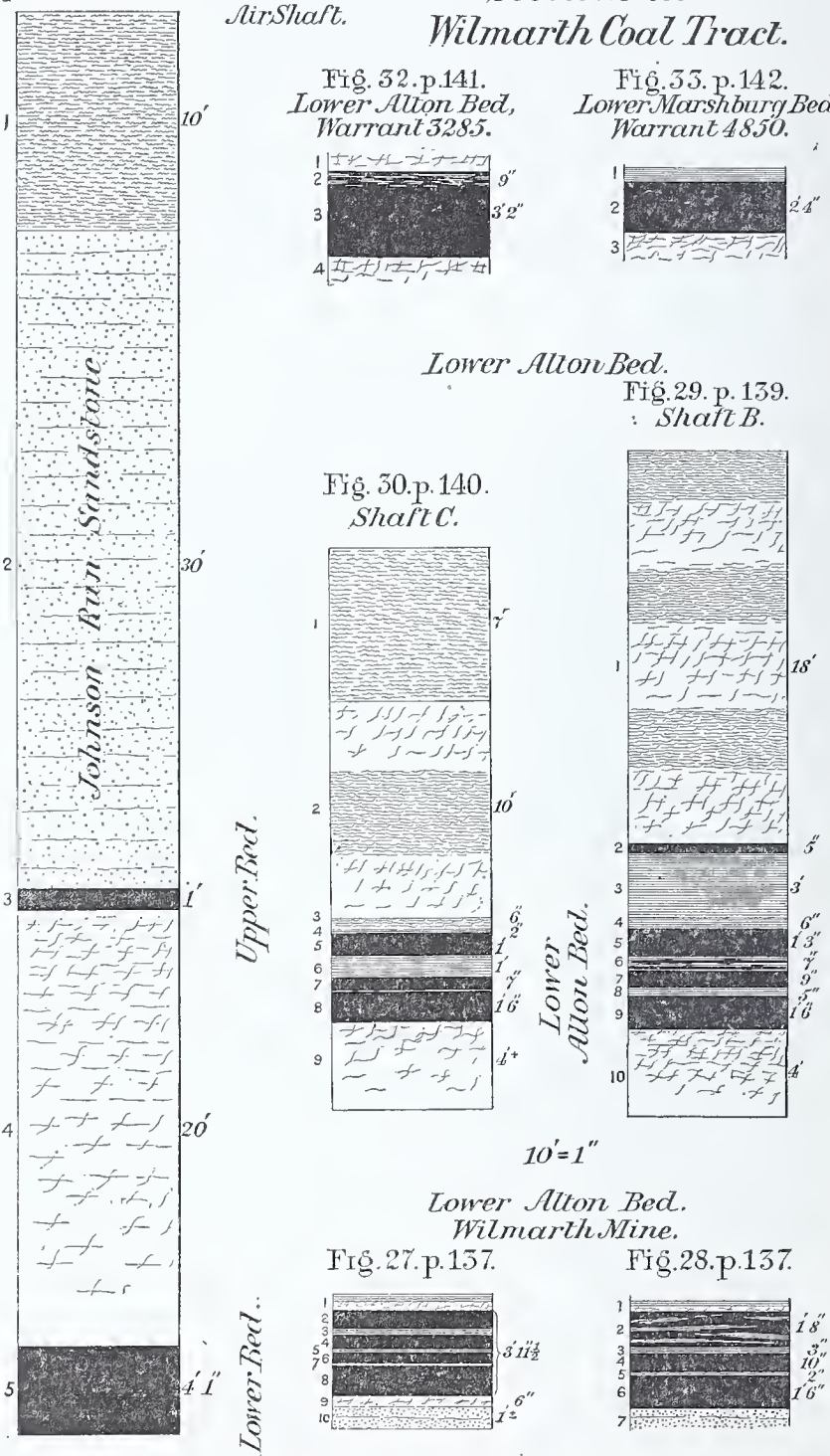
Fig. 32. p. 141.
Lower Alton Bed, Warrant 3285.

Fig. 33. p. 142.
Lower Marshburg Bed, Warrant 4850.

Lower Alton Bed.

Fig. 29. p. 139.
Shaft B.

Fig. 30. p. 140.
Shaft C.



Lower Alton Bed. Wilmarth Mine.

Fig. 27. p. 137.

Fig. 28. p. 137.

underlies this bottom bench varies from 3 to 4 inches in thickness, and has a little streak of coal underneath it.

Below the coal bed which is mined, occurs a second coal bed about 4 feet thick, which has a cannelly structure and contains numerous layers of black slate. The roof of the bed is composed of brown and black slate. The distance between this bed and the one which has been mined is 40 feet. This latter bed is the representative of the *Marshburg Upper coal*, and the sandstone which occurs above it has the characteristic features of the KINZUA CREEK ROCK.

Twenty feet below the bottom of this coal bed, and north of the mine, an outcrop of a fire-clay bed has been dug into, which measures 3 feet thick, with a shaly sandstone between it and the coal.

The outcrop of the *Alton Lower bed* has been carefully traced out by shafts and drifts driven on the bed in a number of localities. Several of these points are indicated on the accompanying map, (page 136.)

At point "A" the outcrop of a coal bed was dug into, but not sufficiently far to find the bed solid. The elevation of the bottom of the coal at this point is 1919 feet.

Above this point a ledge of the JOHNSON RUN SANDSTONE was found, at an elevation of 1950 feet. A sharp terrace is defined at an elevation of 1985 feet, which probably marks, very nearly, the top of the JOHNSON RUN SANDSTONE.

At point "B" a shaft was dug, through a coal bed, the elevation of the top of the shaft being 1950 feet. The section of the strata passed through was as follows (Fig. 29, page 138):

1.	Argillaceous shale and fire-clay, (roof,),	18′	to 18′
2.	*Coal*,	5″	to 18′ 5″
3.	Black slate containing pyrites,	3′	to 21′ 5″
4.	Slate,	6″	to 21′ 11″
5.	*Coal*,	1′ 3″	to 23′ 2″
6.	Black slate containing streaks of coal,	7″	to 23′ 9″
7.	*Coal*,	9″	to 24′ 6″
8.	Slate,	5″	to 24′ 11″
9.	*Coal*,	1′ 6″	to 26′ 5″
10.	Fire-clay,	4′	to 30′ 5″

Immediately above the top of the shaft occurs a hard fine-grained massive sandstone. Three hundred feet west

of the shaft is the edge of a terrace, the elevation of which is 1975 feet.

At point "C," on the map, a shaft was dug, through a coal bed, the elevation of the top of the shaft being 1935 feet. The strata passed through were as follows (Fig. 30, page 138):

1. Soil,	7′	to 7′
2. Argillaceous shale and fire-clay, (roof,)	10′	to 17′
3. Gray shale,	6″	to 17′ 6″
4. Slate containing pyrites,	2″	to 17′ 8″
5. *Coal*,	1′	to 18′ 8″
6. Black slate,	1′	to 19′ 8″
7. *Coal*,	7″	to 20′ 3″
8. *Coal*,	1′ 6″	to 21′ 9″
9. Fire-clay, (floor,)	4′+	to 25′ 9″+

The section of the air shaft which was sunk in the spring of 1880 by Mr. Mayo, north of the mouth of the mines, is as follows (Fig. 31, page 138):

1. Soil, (gravel,)	10′	to 10′
2. Sandstone,	30′	to 40′
3. *Coal*,	1′	to 41′
4. Fire-clay,	20′	to 61′
5. *Alton Lower bed*,	4′ 1″	to 65′ 1″

The first coal bed passed through in the air-shaft is without doubt the representative of the *Alton Upper bed.*

The fire-clay bed (stratum No. 4), which has been found in a number of localities on this tract, would no doubt supply a valuable product for manufacturing purposes. A specimen, taken from near the bottom of the bed 3 feet above the lower coal, was analyzed by the late Mr. J. M. Stinson, with the following result:

Silica,	51.720	
Alumina, (by difference,)	21.736	
Protoxide of iron, (partly as carbonate of the protoxide of iron,)	7.875	Clay comparatively soft and brittle; fracture irregular; color generally bluish black; portions of sample dark pearl-gray.
Titanic acid,	.870	
Lime,	.060	
Magnesia,	2.378	
Alkalies,	4.581	
Water, carbonic acid, and organic matter,	10.780	
Total,	100.000	

Another specimen, which was carefully sampled to represent the average of the bed, was analyzed by Mr. A. S. McCreath, with the following results:

Silica,	56.270
Alumina, (by difference,)	23.225
Protoxide of iron, (partly as carbonate of the protoxide of iron,)	5.400
Titanic acid,	1.190
Lime,	.010
Magnesia,	2.086
Alkalies,	4.039
Water, carbonic acid, and organic matter,	7.780
Total,	100.000

The clay of this specimen was comparatively soft and brittle; had an irregular fracture, and generally a dark pearl gray color.

These analyses bear a favorable comparison with the analyses of clays, from which valuable fire-bricks have been manufactured. The elevation of the summit of the hill, on the slope of which the outcrop of the *Glen Mayo coal bed* is found, is 2005 feet.

Although no coal bed has ever been opened, as far as I know, above the bed which is mined, the ridge would seem to be high enough to include a small area of the *Clarion bed*, which occurs immediately above the top of the JOHNSON RUN SANDSTONE.

Another area of the *Alton Lower bed* is found a little south-west of the center of warrant 3285, as shown on the accompanying map. Two openings have been made in the bed, along its outcrop, which were visited. The elevation of the bottom of the coal bed at the north-western opening is 1895 feet, where the following section was measured (Fig. 32, page 138):

1. Fire-clay, (roof,)	—	
2. *Coal*, slaty,		9″
3. *Coal*,	3′	2″
4. Fire-clay, (floor,)	—	
Total,	3′	11″

No slate was seen in the section of the coal bed measured at this point. Whether this is a characteristic section of the bed, throughout this area, it is impossible to say, as this was the only point where the coal was seen. The same bed is

opened along the south-eastern edge of the outcrop, and the elevation of the bottom of the drift is 1870 feet. The drift had fallen shut at the time that it was visited. The elevation of the summit above and between these openings is 1945 feet. The estimated area underlaid by the coal bed in this locality is about 25 acres. The estimated area of the larger tract to the south-east is about 150 acres.

About 1000 feet north of the mouth of the *Wilmarth mine*, and at an elevation of 1818 feet, a coal bed has been opened, with the following section (Fig 33, page 138):

1.	Black slate, (roof,)	—
2.	*Coal*,	2′ 4″
3.	Fire-clay, (floor,)	—

It was impossible to ascertain the exact thickness of the slate forming the roof of this bed. It is probably, however, not more than a few feet, as the outcrop of a sandstone was found a short distance from the opening, and but a few feet above its top. The upper portion of the coal was soft and slaty, and the lower portion hard and cannelly. This coal would appear to occur below, or in the lower part of, the OLEAN CONGLOMERATE, and is probably the representative of the *Marshburg Lower bed.*

A general section of the strata, from the hill summit on the Wilmarth tract down to the Clarion, bears a close resemblance to similar sections at Ridgway and Bridgetown.

Bog iron ore.

At a number of localities along the Clarion valley, in Ridgway township, evidences have been found of the existence of a bog ore. Several of the deposits of this ore were found and referred to by the assistants of the First Survey, and have been objects of interest to a number of persons owning lands along the valley. No extensive digging has been done, where these deposits have been found, so that their thicknesses have never been determined. I have carefully examined these deposits, and have never found anything which would warrant a hope that commercial iron ore would ever be found. That considerable iron is contained in these ores, there is no question; it is believed, however, that it

would be impossible to use them profitably in a furnace, even as mixing ores, with very much richer ones.

A number of holes have been drilled in Ridgway, with the hope of finding either petroleum or natural gas. The search for petroleum has always met with failure, while a rich gas vein has been developed at one locality, Grant's well. Special reference is made in the first part of this report to the records of these wells, and to the possibilities of finding either oil or gas.

Chapter IX.

Benzinger Township.

Benzinger township lies east of Ridgway, south of eastern Jones, west of Shippen, in Cameron county, and north of Jay and Fox.

The Appalachian divide, or the water-shed separating the waters of the Atlantic from those of the Gulf of Mexico, passes through the township in a nearly north and south direction, dividing it into about equal parts. The eastern half is drained by Trout run and its branches, which flows south-east and empties into the Bennett's branch of the Susquehanna River at Benezette, and by West creek, which follows the Philadelphia and Erie railroad east to Emporium, where it unites with the North and Sinnemahoning creeks to form the main Sinnemahoning. The western half is drained by the branches of Elk creek, the main stream following the P. & E. R. R. west to Ridgway, where it joins the Clarion River, and by Powers' run and Crooked creek and its branches.

The topography of the township seems to be as varied as that of any other township in Elk county. This apparent great variety is probably produced by the wide differences in the development of its surface. In the northern and south-eastern portions much of the area is covered by the primitive forests, although in sections many of the trees, especially the hard woods, have been felled by the lumbermen. Where the forests have not been wholly or partly destroyed, the relief and ruggedness of the topography, which are so characteristic of the hills and valleys along the P. & E. R. R. and the Dagus R. R. up Daguscahonda (Mill) run, where all the trees which could be used, either by the lumberman or tanner, have been cut, are very much obliterated by the dense foliage, which makes the forests of north-western Pennsylvania so beautiful. In the southern

central part of the township, in the vicinity of St. Mary's, the lands have been cleared and cultivated, and the hills are low and rolling, probably more so than in any other section of the county.

The greatest height is in the northern part, east of the center, between the headwaters of Crooked creek and the northern branch of West creek. The elevation of this point was not absolutely determined by the Survey, but it is not far from being of equal height with Jarret's summit, which was determined by Col. Jarret on September 15, 1855, to be 2245 feet above tide.*

Although I am informed that the height of this summit was determined nearly twenty years after the first preliminary line was run through this portion of the State, for a railroad route from the headwaters of the Susquehanna to Lake Erie, yet the line that Col. Jarret ran, at the time that this height was determined, preceded the *location for construction* of any of the preliminary railroad lines which had been previously run.

The location of the P. & E. R. R., as at present constructed, has been questioned by a number of engineers. Be this as it may, the present line, with its first prominent summit at West creek, north of St. Mary's, with an elevation of 1695 feet, and its more western summit at Kane, with an elevation of 2020 feet, shows a much more preferable line, than those preliminary surveys run to the north, of which Col. Jarret's was one, with the eastern summit at an elevation of 225 feet higher than the present highest summit at Kane.

The lowest point in the township is where West creek crosses its eastern line, at an elevation of 1280 feet, the elevation of Rathbun station in Benzinger being 1316 feet, and of Beechwood station, three miles to the east, in Shippen township, Cameron county, being 1252 feet. The greatest range in height in the township is shown by these elevations to be not far from a thousand feet.

Most of the township lies in the *St. Mary's coal basin*, a local name assigned to that part of the *Fourth Bituminous*

*Statement made on authority of Gen. Thomas L. Kane.

basin in the vicinity of St. Mary's. Across the north-western corner passes the *Fourth anticlinal axis*, and across the south-eastern corner the *Third or Boon's Mountain anticlinal axis.* The general direction of the *Fourth anticlinal axis* and of the *St. Mary's coal basin* are, as nearly as can be determined, parallel, having a general course of 45° east of north and west of south.

The *Boon's Mountain anticlinal*, after cutting across the north-western corner of Jay township, makes a sudden deflection to the east, entering the south-western part of Shippen township in Cameron county, a short distance north of its south-western corner.

The *St. Mary's coal basin* is in the form of a flat canoe, rather than that of a trough. The canoe, however, in this case would have its northern end lifted, so that the central line, drawn along the bottom, would dip downward at every point. From this it would appear that the members of the Pottsville conglomerate No. XII, underlying the coal measures, dip in on all sides, except along the line of its axis, from what would be the south-western extremity of the canoe. The dips along the line of axis, commencing at the north-eastern end along the north fork of West creek, are first very rapid, at about a rate of 3 to 4 feet per 100 feet. This dip gradually becomes less and less until the bottom of the basin assumes an almost horizontal position where it crosses the P. & E. R. R. south-west of St. Mary's. It is possible that a reverse dip may ultimately be determined, along the axis towards the north-east, in the vicinity of Laurel run, and if so, it will explain better the features of the topography in this vicinity. From an examination, however, of the conglomerate outcrop, both along the headwaters of Laurel run and Elk creek, it appeared that the rocks were nearly horizontal, along the line of axis, between the two streams.

On some of the old maps of Elk county, where an attempt has been made by local geologists to outline the coal measures, considerable coal has been placed under the summit between Elk creek and Laurel run, and Laurel run and Daguscahonda (Mill) run, immediately south-west of

the prolongation of the axis of the *St. Mary's coal basin*, as outlined on the county map (Plate II). It is my belief, however, that workable coal, especially the *Dagus* or *St. Mary's bed*, will never be found in this area.

A local prejudice exists against considering all the coal areas in the vicinity of St. Mary's as being in the same basin, or designating that basin by the name of St. Mary's. This has probably arisen from the fact that the coal mined by the St. Mary's Coal Company is not considered to be as good a coal as that contained in properties immediately surrounding that of this company. What has led to this conclusion, more than any other fact, has been the appearance of the coal, which to a very slight degree, if at all, can affect its value as fuel. The intelligent coal trade now purchases its fuel from the duty which can be realized from it in its combustion, and not from its appearance. The cause of the difference in the appearance of the coals around St. Mary's is referred to in the detailed description of the St. Mary's Coal Company's mines.

The *Fourth anticlinal axis*, after crossing the western line of the township, deflects to the south, and crosses Elk creek near Daguscahonda. A gap exists in the line indicating the axis of this anticlinal on the county map. This is referred to more particularly in the general description of the structure of the district, described in Part I of this report.

The total thickness of strata exposed above water level in the township is 1000 feet, sub-grouped as follows:

Productive coal measures, No. XIII, Pottsville conglomerate, No. XII, (Kinzua Creek sandstone and Olean conglomerate,)	400′
Mauch Chunk, No. XI, Pocono, No. X,	575′
Red Catskill, No. IX,	25′±
Total,	1000′

The highest stratum is to be found under the summit of Patton Hill, near the house of Mr. Patton (Supt. of the St. Mary's Coal Co.) This consists of a rotten sandstone, shale and slate, and occupies the position in the series immediately over, what I believe to be, the representative of the

Fig. 34. p. 150.
St. Mary's Basin,
St. Mary's Mines.

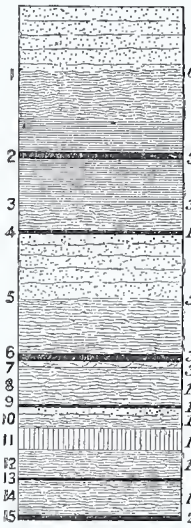


Fig. 37. p. 161.
St. Mary's Basin,
Tannerdale Mine.

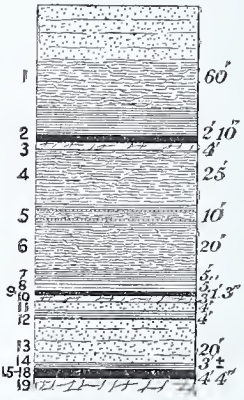


Fig. 35. p. 154.
Pottsville No. XII. Measures,
St. Mary's Basin.

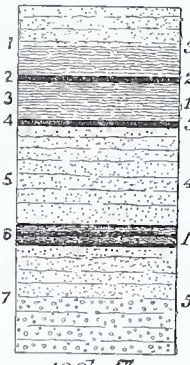


Fig. 36. p. 158.
Lower Kittanning Bed,
(average)
St. Mary's Mines.

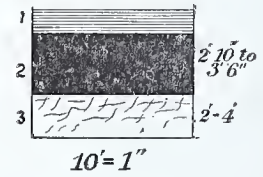


Fig. 39. p. 163.
Lower Alton Bed
east of
Tannerdale chutes.

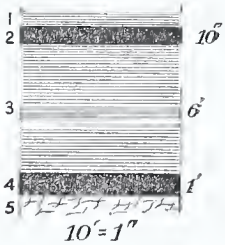


Fig. 38. p. 163.
Upper Alton Bed,
Shobler Farm.

Upper Kittanning coal bed. The bed was dug through in a well near the house. Its bottom is 90 feet vertically over the top of the *Dagus bed* in the St. Mary's mines.

The lowest stratum is found at the westernmost northeastern corner of the township, where the upper part of the RED CATSKILL ROCKS are lifted, to such a height, by the *Kinzua-Emporium cross anticlinal axis* as to be found outcropping. The geological map of the county would indicate that this corner of the township just touches the top of the Catskill rocks. I believe, however, that the outcrop of the Catskill strata, which was located here by Mr. Sheafer, does not quite rise to the corner of the township, if my information in regard to its location relative to North Fork creek is correct. This is the only locality in Elk county, where the surface has been cut sufficiently low to expose the rocks of the Catskill formation.

Although our knowledge of the strata underlying the township, as gathered from a study of those which outcrop, would end with the top of the Catskill, yet the borings which have been made by the St. Mary's Oil Company on Silver creek near St. Mary's, and by Mr. Jonathan Watson at Johnsonburg, give us very careful sections of the strata for 1000+ feet into the CHEMUNG SHALES, and possibly into those of the PORTAGE. Sufficient facts have not been obtained from deep drillings in this part of the State to determine the exact position of the horizon between the Chemung and Portage rocks.

The name "PRODUCTIVE COAL MEASURES" is indefinite, as used in a general sense for any locality in the *bituminous coal fields;* used in a special sense for Benzinger township, it embraces the measures which include the productive coal beds, or those from the top of the KINZUA CREEK SANDSTONE to the highest rock in Patton hill. These are represented by the following section, which has been compiled from observations and measurements made in the vicinity of St. Mary's.

The individual strata which are represented in this section will not be found to vary very considerably at any point, either in general thickness or character. Local vari-

ations do, however, exist, which may be detected by a comparison of the sections reported at special points. These variations consist largely in coal beds becoming more slaty, or entirely replaced by slate. In places, however, the bed is entirely cut out, and is not represented even by a carbonaceous slate. In such cases, special features of the strata, at the point where the bed should exist, are easily discernible by the experienced geologist. Other variations exist, in the sandstone strata becoming more slaty or shaly, or the slates and shales becoming more massive and sandy. The section is as follows (Fig. 34, page 148):

1.	Gray sandstone, shale, and slate,	67′
2.	*Coal, Kittanning Upper,*	3′
3.	Sandy slate and shale,	33′
4.	*Coal, Kittanning Middle,*	1′ 6
5.	Sandstone and shale,	55′
6.	*Coal, Dagus, Kittanning Lower,*	3′
7.	Fire-clay,	3′
8.	Shale,	17′
9.	*Coal,*	1′ 4″
10.	Sandstone and shale,	10′
11.	Limestone and shale, *Clermont, Ferriferous,*	10′
12.	Shale,	13′
13.	*Coal,*	5″
14.	Shale,	16′
15.	*Coal, Clermont, Clarion,*	2′
	Total,	235′ 3″

The Lower Productive measures are 235 feet thick at St. Mary's, and contain only one coal bed which has proved workable to any great extent, that is, the *Dagus, C, or Kittanning Lower bed*, which is the only one at present being worked at all the mines in Elk county. The *Clermont or Clarion bed* has been mined to a limited extent, but has never proved a desirable bed. It was mined by Mr. D. Eldridge on Silver creek, immediately north of St. Mary's.

The rocks of interval No. 1 of the section form the top of the Patton hill, and include the *Freeport sandstone*, and possibly the *Freeport limestone* and *Freeport Lower coal bed*, although neither of the latter have been discovered. Ten miles south of St. Mary's the *Freeport limestone* is only 40 feet above the *Kittanning Upper coal*, and the

Freeport Lower coal is only 50 feet above the same bed; at St. Mary's the top of the hill is 67 feet above the latter. The total absence of the *Freeport coal and limestone* here argues, either a disappearance of the beds to the north-east, or a considerable thickening of the *Freeport sandstone* in the same direction.

The *Kittanning Upper coal* (stratum No. 2) is reported to have been found in a well dug near Patton's house. This is the only place in the township where it has been found. The bed is said to be 3 feet thick, but has never been thoroughly tested.

The sandy shale and slate underlying the *Kittanning Upper coal bed* varies very slightly. It is always very argillaceous, and seldom contains any massive sandstone strata.

The *Johnstown Cement bed*, which occurs between the *Kittanning Middle and Upper beds*, has not been found in Benzinger. It is, however, well defined in the sections of Horton and Fox townships to the south-west.

The *Kittanning Middle coal* (stratum No. 4) has been found on the Cascade Mining Company's tract, (Kaul and Hall.) It is only 1 foot 6 inches thick, and not workable.

The *Dagus or Kittanning Lower bed* (stratum No. 6) is the principal and most important coal. It has been worked in the mines of the St. Mary's Coal Company, Cascade mines, Tannerdale mines, and Keystone mines, and has been opened and tested on a number of other properties. This bed is reported by Professor Rogers* to be the same as those "of Allis, Nist, Bucheit, Glot, and Anthony, in which its thickness varies from 3 feet to 3 feet 6 inches. The roof and floor of the coal are usually thin bands of bituminous slate. This same bed was cut in Corbe's well, and may readily be opened at various points on the hills."

The Kittanning Lower bed is, without doubt, the same as that which is mined by the North-western Mining and Exchange Company near Centerville, which is there locally called the *C bed*. It also occupies the same geological hori-

* Final Report, Vol. II, p. 552.

zon as that in which *Gen. Kane's gas vein* is found. This bed is now being worked at the Bucktail mines on the Roberts lot in Jones township.

A number of local geologists have always considered the *St. Mary's bed* to be very much lower, geologically, than the *Lower Kittanning bed*; as to the error of this conclusion, there would appear to be now no question of a doubt, in view of the facts presented in this report. As to the conclusion regarding the fuel value of the different coals, the question has been solved practically by the coal trade, and is not one to be entered into here.

The interval between the *Dagus coal bed* above and the *Clermont coal bed* below, composed of strata Nos. 7 to 14 inclusive, of the general section, is one of the most important, in a purely geological sense, in the county. This is the interval which contains the *Ferriferous or Clermont limestone*, whose presence in the series at St. Mary's has long been questioned.

Prof. Rogers,* in speaking of this limestone, says: "On the higher grounds in the southern and western parts of the town (St. Mary's) limestone is found at various places. It is a very hard, dark blue rock and burns to a light gray, strong lime. The thickness of the stratum has never been tested, but it certainly exceeds 3 feet. The presence of this bed adds greatly to the value of these lands for agricultural purposes. We have before expressed our conviction that it is the same stratum which lies at the base of our section at Kyler's, on Little Toby creek, and it may prove to be the southern prolongation of the great bed seen at Wilcox's. It appears on the Olean road near St. Mary's, and is evidently beneath the bed of coal that has been mined east and northeast of the town."

Prof. Rogers also reports that this limestone was found on Mr. Shaefer's farm north-east of St. Mary's. A determination of the geological position of this limestone, by the First Survey, seems to have depended solely upon the finding of scattered blocks of limestone in the ploughed fields in the vicinity of St. Mary's. It is currently maintained,

* Final Report of First Survey, Vol. II, p. 552.

that these fragments of limestone were not a natural occurrence, but that they were placed there, either with a view of purposely deceiving the geologists of the Survey, or of enriching the land where they were found. There are no facts, however, to substantiate either explanation.

Although the assistants of the First Survey labored under great difficulties and disadvantages, in their survey in the north-western part of the State, which was at that time an undeveloped and almost unexplored region, they deserve, however, the greatest credit for the work they accomplished. There is no question, but that some of their conclusions have been disproved by subsequent developments; yet, at the same time, the general accuracy of the work, which was done in this region, demands my greatest admiration, when I recall the difficulties which, during the past few years, beset my own investigations, in a region where many developments have been made, since the assistants of the First Survey made their examination, and into which, at that time, the mineral prospector had scarcely entered.

I not only saw the limestone nodules in the fields northwest of the railroad station at St. Mary's, but have been told, on good authority, that pieces of the stone have been gathered here, which have been burned into lime.

In a railroad cut, near the West Creek summit, about one mile north of the coal chutes of the St. Mary's Coal Co. are to be found, contained within an interval of 10 feet, outcrops of thin beds of limestone and lime-shale, varying in thickness from 1 to 3 inches, and alternating with soft argillaceous shale. The highest limestone seam found in this cut was 31 feet below the *St. Mary's bed.* From a careful survey made in this vicinity, there can be no doubt but that these thin limestone bands occur in the same geological horizon as the limestone stratum, from which the broken pieces of limestone in the field about St. Mary's come, and that both are representatives of the *Ferriferous limestone.* The various types, under which this limestone bed is found to exist, in the county, are referred to in the general report of the district, and it is important for the field geologist to become familiar with them, before attempt-

ing to systematize the coal measure sections throughout this portion of the State.

The strata composing the interval, between the limestone and the *Dagus bed* above and the *Clermont bed* below, are very similar, and generally consist of gray argillaceous shales and slates, with sometimes thin but sporadic beds of sandstone included. In the vicinity of St. Mary's there is locally found a thin *coal bed* in both of the intervals, (strata Nos. 9 and 13); in the vicinity of the *Cascade mine* it was reported to me that the *upper bed* had been opened and found to be 1 foot 4 inches thick, whereas the *lower bed* was only a streak of coal, at one place but 5 inches thick.

The *Clermont or Clarion bed* has been worked to a limited extent on the Monastery lands, east of Silver creek, about three quarters of a mile north-west of the St. Mary's railroad station. This bed has been opened for a great many years, and was examined by the First Survey, although it has only been mined within recent years, by Mr. D. Eldridge. This bed has been prospected for, by drill-holes bored by the St. Mary's Coal Company near their coal chutes, along the line of the P. & E. R. R., but the bed was not found. Its outcrop has been discovered at several points in the township, other than along Silver creek, but the bed has not been found of workable dimensions, nor did it contain coal sufficiently pure to offer an inducement for further exploration.

Pottsville Conglomerate, No. XII.

This formation at St. Mary's is 161 feet thick and is composed of the following strata (Fig. 35, p. 148):

1.	Sandstone and shale, JOHNSON RUN SANDSTONE, . . .	32
2.	*Coal, Alton Upper,*	2′ 7″
3.	Shale, ...	18′
4.	*Coal, Alton Lower,*	3′
5.	Sandstone, KINZUA CREEK SANDSTONE, ...	45′
6.	Shale and *coal,*	10′
7.	Sandstone and conglomerate, OLEAN CONGLOMERATE,	50′
	Total, ...	160′ 7″

The JOHNSON RUN SANDSTONE, the top sandstone mem-

ber of the conglomerate, whose thickness is 32 feet, and which is composed of shale and sandstone, is thinner at St. Mary's than at any point, in the county, where a meaurement of it was made, except on the Field tract in Jones township. In fact, at only two other points within the three counties of McKean, Elk, and Cameron, one west of Norwich in McKean county where this interval measured 24 feet, and the other in the *Cameron coal basin* where its thickness was 28 feet, was the *Johnson Run* interval found about the same thickness as on the Field tract.

The *Alton coal beds* have never been found in Benzinger of sufficient purity to prove workable. The upper bed was opened by Mr. Eldridge on the Keystone tract, but the opening was abandoned as the coal was found to be slaty.

The KINZUA CREEK SANDSTONE and OLEAN CONGLOMERATE, forming the middle and lower massive members of the POTTSVILLE, have about the same thickness and character of constitution as elsewhere in the county. The outcrop of a coal bed was found between them, in the western part of the township.

Mauch Chunk, No. XI.

This formation, in the basin west of St. Mary's, is represented by a slate about 10 feet thick immediately underlying the OLEAN, which sometimes contains a thin and extremely sporadic bed of coal. No outcrop of red shale was found within the limits of the township, in this horizon. From surface features, however, it is probable that the slate is sometimes red. On the road between St. Mary's and New Flanders an outcrop of the red shale is found at several points. A thickness of 25 feet has been determined, but it is possible that the thickness of No. XI is as great as 50 feet in the northern part of the township.

Formations Nos. X, IX, and VIII in the St. Mary's oil well.

The record of this well is given just as it was reported to the Survey by Mr. W. W. Ames, who had copied it from

the driller's own book. I am informed that the undescribed intervals generally contained blue and gray slate.

1.	Drift,	32′ to 32′
2.	Sand,	18′ to 50′
3.	Blue slate,	45′ to 95′
4.	Sand,	25′ to 120′
5.	Blue slate,	140′ to 260′
6.	Sand,	16′ to 276′
7.	Blue slate,	124′ to 400′
8.	Sand,	20′ to 420′
9.	Blue slate,	205′ to 625′
10.	Red rock,	335′ to 960′
11.	Blue slate,	12′ to 972′
12.	Sand,	49′ to 1021′
13.	Blue slate,	369′ to 1390′
14.	Red rock,	25′ to 1415′
15.	Slate,	35′ to 1450′
16.	Reddish rock, (only a streak.)	
17.	Blue slate,	220′ to 1670′
18.	Sand,	44′ o 1714′
19.	Black slate and shells with a few red streaks,	286′ to 2000′
20.	Sand,	10′ to 2010′

The record of this well furnishes us with a fairly good section of the Pocono rocks No. X, Red Catskill No. IX, and Chemung No. VIII. I have grouped the rocks in this well as follows: Mauch Chunk No. XI and Pocono No. X, strata Nos. 3 to 9 inclusive, 575 feet; Catskill No. IX, stratum No. 10, 335 feet; Chemung No. VIII, strata Nos. 11 to 20 inclusive, 1050 feet. The correspondence between this section, that of the Johnsonburg well, that compiled from surveys and measurements, and the record of the Cameron oil well at Cameron, is striking. This is referred to in the general description of the lower Carboniferous and Devonian rocks, in the general report on the district (Report RR Part I).

A small "gas" vein was struck in the St. Mary's drill hole at a depth of 550 feet; at 972 feet a very much larger one was found. At 450 feet and 1020 feet salt water was encountered. The *Bradford Oil sand* is at least 250 feet below the bottom of the St. Mary's test well. Although some persons have credited the report that some oil was found in this well, I very much question the fact, nor do I believe that a small showing of oil found in any well, in this vicinity,

would foreshadow the finding of a productive oil area in the vicinity of St. Mary's.*

St. Mary's Coal Company.

The St. Mary's Coal Company is the oldest coal mining company, which is now engaged in mining, within the limits of Elk county. The mines which have been operated, for so many years, are situated on either side of the Philadelphia and Erie railroad, one mile north-east of the village of St. Mary's. Ground was first broken at these mines on the first of September, 1863, and the mining of coal commenced on the first of July, 1864. The bed which is being worked is the *Dagus bed* (Reports R and RR) or *Lower Kittanning* (Reports H to H^5 and V, VV) or "*C*" *coal bed* of the local geologists. As has been stated, this bed is identical with that worked by the North-western Mining and Exchange Company, at the head of Toby creek, and with "*Kane's gas vein*", opened on the Roberts lot, Jones township.†

The accuracy of the St. Mary's section reported by Prof. Rogers (Final Report, Vol. II, page 552) has been questioned. When it is considered how imperfect the development was, at the time of the work of the First Survey, it is surprising that the general structure of Rogers' section is as accurate as it is. Some of the conclusions are wrong, but the general features of the section are correct.

Numbering the coal beds in Prof. Rogers' section (Fig. 384 of his report) from bottom up, the comparison with the coal beds of this report is shown as follows:

Bed No. 5, *Kittanning Middle bed.*
" No. 4, *Dagus* "
" No. 3, *Clermont* "
" No. 2, *Alton Upper* "
" No. 1, *Alton Lower* "

* For records of the holes which have been drilled in Elk county, in search of oil and gas; a discussion of the possibility of finding a productive oil territory, in the county; and a general description of the geological formations below the coal measures, the reader is referred to the first part of this report.

† For discussion of identity see general description, Part I.

The only bed of the series which has proved workable on the company's property is the *Dagus coal.*

A general section of the coal beds and accompanying strata, which are actually known to exist on the St. Mary's Coal Company's property, resembles the general section of the township, already given. (See page 150.)

The *Dagus bed* is mined by the St. Mary's Coal Company, on either side of the Philadelphia and Erie railroad. The elevation of the bed at the mine mouth, on the west side, is 1775 feet, or 85 feet above the railroad at the foot of the chutes. The bed was formerly worked at the now abandoned mine, which is 1520 feet north of the head of the plane, or about 1400 feet, in an air line, north 33° west of the drum house. From the mouth of the abandoned mine to the mouth of the working mine, on the east side of the railroad, the distance is about a third of a mile south 85° east.

The seam consists of one solid bench of coal, averaging about 3 feet in thickness. The minimum thickness is 2 feet 10 inches and the maximum 3 feet 6 inches. (Fig. 36, page 148.)

The floor of the bed consists of a rather hard, gray, siliceous fire-clay, varying from 2 to 4 feet thick, and the roof of a blue slate. On the north-west side of the railroad, an air shaft was sunk, through 25 feet of the slate, which was found to have a constant character throughout.

The strata, extending from the bed to the top of the hill, are cracked and fractured throughout, which permits the flow of surface water down to the bed. The rocks overlying the bed are very ferruginous, and the filtering water dissolves the iron out and carries it down to the coal, together with suspended clay particles. This fact accounts for the rusty and dirty appearance of the St. Mary's Coal Co.'s coal. This condition of the coal is generally accounted for by the lack of sufficient cover. The cover is thick enough, but not good enough. The summit of the hill near the house of Mr. Patton, supt. of the St. Mary's Coal Co., is 160 feet above the top of the underlying *Dagus bed.*

Mr. Patton dug through a coal bed 3 feet thick in a well near his residence. This bed occurs 90 feet vertically above

the *Dagus seam.* According to Mr. Patton there is from 6 to 8 acres underlaid by this bed.

The *Clermont coal bed* was found on the west side of the railroad, about a quarter of a mile south-west of the chutes. At the outcrop it measured 1 foot 3 inches in thickness. The coal occurs about 65 feet below the *Dagus bed.* It was searched for immediately in the rear of the chutes, but the coal seemed to be cut entirely out, as the black roofing slate was found in place, immediately on top of the fire-clay floor. A shaft was sunk 30 feet down to the fire-clay bed, through a dark gray shale and slate, with occasional thin seams of sandstone. This is the general character of the strata included between the *Clermont* and *Dagus beds.*

Two bore holes were drilled on the company's property, one directly back of the chutes to a depth of 70 feet,* which stopped at the bottom of a coal bed reported to be 4 feet to 4 feet 2 inches thick. The top of the bore hole was about 10 feet below the position of the *Clermont coal.* The bed which was drilled through is, therefore, about 75 feet below this coal, and is without doubt the representative of the *Alton Lower* coal. At this point the *Alton Upper* and *Middle beds* are not represented. This statement is confirmed by a shaft, which was dug on the east side of the railroad near the chutes. The top of the shaft was located about ten feet below the position of the *Clermont bed.* It went through gray and blue slate and an occasional sandstone band, but no coal bed was encountered. The bottom of the shaft must have been 10 to 15 feet above the *Alton Lower coal bed.*

At the mouth of the mine (drift No. 2), on the east side of the railroad, the elevation of the coal is 1750 feet, or about 25 feet lower than at the mine mouth on the west side. This shows a dip to the north of east. The dip of the bed at the east mine is about $6\frac{2}{3}$ feet to 100 feet, in a direction north 85° west. The coal from the present mine (1879) is taken through a tunnel which is 1200 feet long, course N.

* Mr. E. E. Willard of Ridgway informed me that this hole was 74 feet deep and that it is very doubtful if as much coal was obtained as reported.

85° W.; the lower end of the tunnel is known as drift No. 2. The mouth of the working mine is about 600 feet north 70° west from the upper end of the tunnel. The dip of the coal bed between these two points is about 9 feet (at rate of $1\frac{1}{2}'$ per 100′) towards the tunnel.

The course of the main mine entry is about north 40° east, and the floor of this entry is very nearly level. The length of this entry is 1500 feet, and it pierces the hill from daylight to daylight. The average thickness of the *Dagus bed* in this mine is 3 feet. The greatest amount of cover here is said to be 40 feet. The blue slate immediately on top of the coal has been shafted through to a distance of 17 feet. Three feet of slate, directly on top of the coal bed, is extremely argillaceous, and deteriorates into a clay upon weathering. One hundred yards from the mouth of the drift, the roofing slate is replaced by a hard, massive gray sandstone, containing a large number of plant remains and clay and iron balls.

One of the most interesting and unusual occurrences in Elk county is a fault in the coal bed, at the south-east edge of the sandstone roofing. The coal bed drops 4 feet to the south, the line of fault running north-east and south-west, nearly at right angles to the gangway. Faults of this character are extremely rare in the bituminous coal fields,* and the occurrence conjointly of the sandstone roof and fault gives us an indication of the age of the latter. The break in the coal

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*The only other fault, beside the St. Mary's, discovered in McKean, Cameron, Elk and Forest counties, is the Sinnemahoning-Portage fault, in the south-eastern corner of McKean county, about a mile north of the McKean-Cameron line. (See Report R, page 34.) Both of these faults, although very small, are extremely interesting, from the rareness of such irregularities of structure.

The Sinnemahoning-Portage fault is very different from the St. Mary's, and represents a probable oblique slip of 200 feet in the Chemung rocks. This break took place long after the St. Mary's, which is evidently of Carboniferous age. The topography and rock section in south-eastern McKean would seem to indicate the fact that the fault at this point took place after north-western Pennsylvania had, for the last time, been raised above water level, and erosion had begun. Some of the features of the subsequent erosion were apparently determined by the fault.

Numerous faults have been discovered in the coal measures in Clearfield county. An upthrow fault, in the vicinity of Moshannon, measures 90 feet. (See Report H⁷.)

bed took place, without doubt, during the time of the deposition of the roofing slates. Some local elevation or depression must have taken place, which faulted the bed, and at the same time changed the direction and force of the depositing currents, and the character of the sediments. The width of the sandstone roof, measured along the gangway, is 30 yards north-west and south-east. Its length is possibly 40 yards more or less. The thickness of the sandstone is not known. At one place 6 feet has been cut through, immediately above the bed, without showing a less massive character.

Tannerdale mine.

This mine was originally worked by the Tannerdale Coal Mining Company. It is at present controlled and worked by the St. Mary's Coal Company. The strata are much the same as those found at St. Mary's, although they do not extend as high up in the coal measures by 100 feet.

The following is a section constructed on and in the vicinity of the tract: (Fig. 37, page 148).

1. Sandstone, shale and slate,		60′	
2. *Coal, Dagus, Kittanning Lower*,		2′	10″
3. Fire-clay,		4′	
4. Gray argillaceous shale,		25′	
5. Gray shale and black slate, containing limestone bands and limestone concretions. *Ferriferous limestone*,		10′	
6. Gray shale,		20′	
7. Gray slate,		5′	
8. Black and gray slate,		5′	
9. *Coal, Clermont, Clarion*,		1′	3″
10. Fire-clay,		3′	
11. Hard argillaceous sandstone,		4′	
12. Gray and black slate,		4′	
13. Sandstone,		20′	(?)
14. Black slate,		3′±	
15. Bone and bony *coal*,	*Alton Upper bed*,		4″
16. *Coal*,		1′	4″
17. Blue slate,		1′	6″
18. *Coal*,		1′	2″
19. Fire-clay,		—	
Total,		171′	5″

The only bed which has been mined on the tract is the *Dagus*. The mine is located about 3 miles north-east of St.

Mary's, and about ½ mile south of the Philadelphia and Erie railroad. The elevation of the mouth of the mine is about 1750 feet. At this point there is 60 feet of cover to the coal bed. An air shaft has been sunk to the coal, at a point 300 yards south 60° east from the mouth of the drift. The dip of the bed between the two places is 2½ feet per hundred, north 60° west. The coal is 2 feet 10 inches thick, has a hard, dark-gray slate roof, and is underlaid by a bed of fire-clay 4 feet thick. In the eastern part of the mine the dip changes from a north-west to a south-east dip, showing the presence of an anticlinal.

The following is an analysis of the coal, (A. S. McCreath :)

Water,	.990
Volatile matter,	38.355
Fixed carbon,	52.826
Sulphur,	2.044
Ash,	5.785
	100.000
Coke per cent.,	60.655
Color of ash,	reddish gray.
Fuel ratio,	1; 1.37

The coal is dull black and is more or less coated with oxide of iron. It contains partings of pyrites, which are partly decomposed.

The shale, slate, and limestone bands, representing the *Ferriferous limestone*, are exposed in a railroad cut about midway between the St. Mary's Coal Company's chutes and the Tannerdale chutes (see page 153).

The *Clermont coal bed* has been opened on the *Shobler farm*, about 1 mile east of the Tannerdale mine. The bed is not of workable size, being only from 1 foot to 1 foot 3 inches thick. It is overlaid by a black and blue slate, and contains balls of carbonate of iron. The elevation of the coal is 1675 feet above tide.

The *Alton Upper bed* is also opened on the *Shobler farm*, at an elevation of 1660 feet. The bed is composed of two benches, with a stratum, between, of blue slate 1 foot 6 inches thick. The total thickness of the bed is 4 feet, in section as follows (Fig. 38, page 148):

1. Black slate,		—
2. Bone and bony *coal*,		4″
3. *Coal*,	1′	4″
4. Blue slate,	1′	6″
5. *Coal*,		10″
6. Fire-clay,		—
Total,	4′	0″

The coal is coated with oxide of iron, contains partings of iron pyrites, and is high in ash. The bed resembles very much the *Alton Upper coal* opened on the *Keystone tract*, both in its thickness and the quality of the coal which it produces. As far as at present proved on this farm, it can hardly be judged to be a bed which could be profitably mined.

In a railroad cut, about 600 feet east of the Tannerdale coal chutes, two small coal beds were passed through. The position of the coals is shown in a section constructed at this point (Fig. 39, page 148):

1. Gray slate,		—
2. *Coal*,		10″
3. Gray and black slate,	6′	
4. *Coal*,	1′	
5. Fire-clay,		—
	7′	10″

One or both of these coal beds represent the *Alton Lower* coal.

Keystone mines.

The old *Keystone Company's * tract* lies about 1½ miles due east of the railroad station at St. Mary's. The mines are at present abandoned. They were last worked by Mr. D. Eldridge, lessee. The following is a section of the strata which have been proved on the tract: (Fig. 40, page 164.)

1. Partly concealed. Composed principally of gray slate, shale and sandstone,	105′	±
2. *Coal, Dagus, Kittanning Lower*,	3′	
3. Shale,	20′	
4. *Coal*,	1′	4″

* This company is composed of Bostonians, and was originally organized under the name of the Benzinger Company, of which Dr. O. S. Saunders was president and Mr. William H. Finney, secretary and treasurer.

Fig. 40. p. 163.
St. Mary's Basin
Keystone Mines.

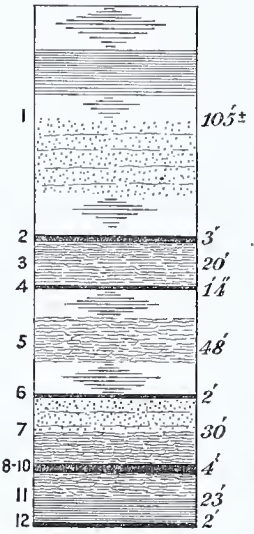


Fig. 42. p. 167.
St. Mary's Basin
Cascade Mines.

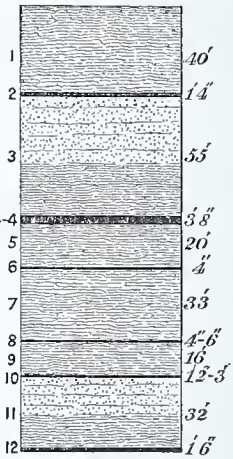


Fig. 44. p. 169.
St. Mary's Basin
Silver Creek Mines.

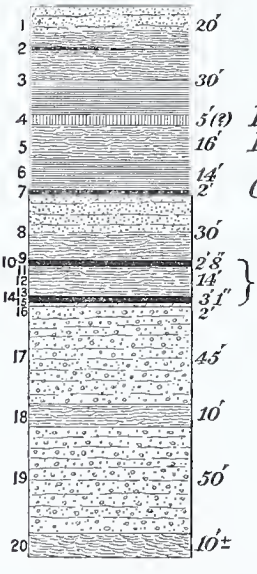
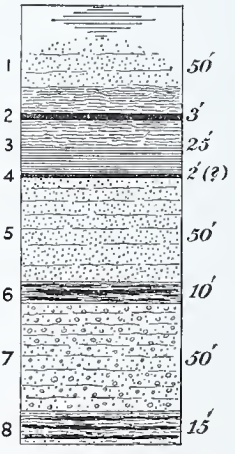


Fig. 47. p. 173.
St. Mary's Basin
Seahonda Tract.



100' = 1"

5.	Partly concealed. Principally gray shale,		48′
6.	*Coal, Clermont, Clarion,*		2′
7.	Sandstone and shale, JOHNSON RUN,		30′
8.	*Coal,* 1′ 6″		
9.	Bony *coal* and slate, 1′ to 15″	*Alton Upper,*	4′ ±
10.	*Coal,* 1′ to 15″		
11.	Soft shale and slate,		23′
12.	*Coal, Alton Lower,*		2′
	Total,		238′ 4″

The highest coal bed which has been proved on this tract is the *Dagus*, which has been called locally the "*C*" *bed.*

The elevation of the extreme western opening is 1825 feet, and the coal bed is 3 feet thick, composed of one solid bench of coal. The roof consists of a good, hard, black slate, except on the outcrop, where it is very soft and treacherous. According to Mr. Eldridge, the roof slate in the western part of the mine was replaced by a hard sandstone. There is another opening on the *Dagus bed* east of the one just described, the elevation of which is 1835 feet, showing a dip of 10 feet toward the west.

The east mine of the St. Mary's Coal Company is about $1\frac{3}{4}$ miles north-west of this latter mine. The difference in elevation between the two mines is 85 feet, which shows an average dip of about 48 feet to the mile, in a north-west direction.

The center of the *St. Mary's coal basin* crosses the Philadelphia and Erie railroad in a north-east and south-west direction, about a quarter of a mile south of the chutes of the St. Mary's Coal Company.

Two very thin seams of coal are said to exist 5 to 10 feet apart, and about 40 feet above the *Dagus bed.* Twenty feet below this latter bed a coal bed has been opened, which was 1 foot 6 inches thick on the outcrop.

The interval No. 5 of the section is mostly concealed. I did not find any limestone on, or in the vicinity of, the *Keystone property.* It should be found a few feet below the last coal described. The *Clermont coal bed* has been found in a number of localities. It was opened not far from the old barn, and some 20 feet above, at an elevation of 1760 feet. A drift was driven in the bed not far from the old

Fig. 43. p. 168.

Lower Kittanning Bed
Cascade Tract.

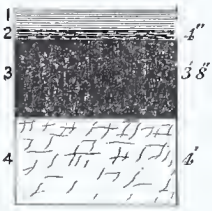


Fig. 41. p. 167.

Upper Alton Bed
Keystone Tract.

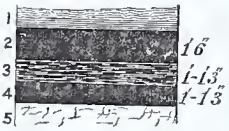


Fig. 45. p. 171.

Upper Alton Bed
Silver Creek Tract.

Fig. 48. p. 175.

Upper Alton Bed
Seahonda Tract.

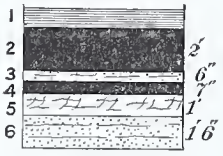


Fig. 46. p. 172.

Lower Alton Bed
Silver Creek Tract.

10' = 1"

Sections of Coal beds in the vicinity of St. Mary's, adjacent to the line of the Philadelphia and Erie Railroad.

Switch-back. The coal was poor, and the opening was finally abandoned by Mr. Eldridge, after being worked 3 or 4 months. The bed varied from 1 foot 6 inches to 2 feet in thickness, although it was generally found to be less than 2 feet. The coal contained a great deal of pyrites, and was very bony.

The *Alton Upper bed* has been opened in a ravine a quarter of a mile, more or less, east of the blacksmith shop and old Switch-back. Here the following section was measured (Fig. 41, page 166):

1. Gray shale and black slate,	—	—
2. *Coal*,	1′ 6″	
3. Bony *coal* and slate,	1′	to 1′ 3″
4, *Coal*,	1′	to 1′ 3′
5. Fire-clay,	—	—
Total,	3′ 6″+	

Two car loads of coal were shipped from this opening and tried in the engines of the Philadelphia and Erie railroad; the coal, even after being hand-picked, proved worthless, as a steam coal, and was condemned.

This same bed was opened near the old blacksmith shop; the coal was badly crushed and very poor. A shaft was afterward sunk below this bed, through 23 feet of soft shale and slate, to a lower bed, which was found to be 2 feet thick. Black slate occurred immediately on top of the coal, which was itself very bony and slaty. This latter coal is the representative of the *Alton Lower bed.*

Cascade mines.

These mines are east of St. Mary's, and but a short distance from the *Keystone Company's tract.* They were opened in the early part of the winter of 1878, and are operated by Messrs. Kaul and Hall.

The following section was constructed, conjointly from observations made on the ground and measurements reported by Mr. James Black, mine superintendent (Fig. 42, page 164):

1. Sandy shale,	40′
2. *Coal, Kittanning Middle,*	1′ 4″
3. Sandstone and shale,	55′
4. *Coal, Dagus, Kittanning Lower,*	3′ 8″

5. Shale,	20′
6. *Coal*,	4″
7. Shale, &c.,	33′
8. *Coal*,	4″ to 6″
9. Shale,	16′
10. *Coal, Clermont, Clarion*,	1′ 2″ to 3′
11. Shale and sandstone,	32′
12. *Coal, Alton Upper*,	1′ 6″
Total,	205′ ±

The *Dagus bed* is the only coal which has proved workable, and the only coal which has been mined on this tract. The elevation of mine No. 1 is 1815 feet. The coal averages about 3 feet 4 inches thick, and the dip is 1 to 1½ feet to every hundred feet, to the north-west.

The same bed has been opened in a second drift, at an elevation of about 1840 feet. The following represents a section of the coal (Fig. 43, page 166):

1. Hard, black and gray slate,	—
2. Bony and slaty *coal*,	4″
3. *Coal*,	3′ 8″
4. Fire-clay,	4′
Total,	8′

The *Dagus bed* in this mine is frequently 3 feet 11 inches thick, and at times attains a thickness of 4 feet 2 inches. The Cascade coal has a deep, black, shining luster, is somewhat coated with silt, and contains considerable pyrites, which is sometimes partially decomposed. On analysis it gave (A. S. McCreath):*

Water,	.990
Volatile matter,	40.585
Fixed carbon,	49.416
Sulphur,	3.369
Ash,	5.640
	100.000
Coke, per cent.,	58.425
Color of ash,	pink.
Fuel ratio,	1: 1.22

Silver Creek mine, Monastery lands.

This mine is located on the east side of Silver creek, di-

* Other analyses have been made of the coal from the beds throughout Elk county. These are given in Part I of this report.

rectly north-west of St. Mary's. A number of coal openings have been made on the tract, and the strata have been fully explored, from the base of the OLEAN CONGLOMERATE, which is the lowest member of the POTTSVILLE CARBONIFEROUS CONGLOMERATE No. XII, to some distance above the position of the *Dagus or Kittanning Lower coal bed.* The *Clermont* and *Alton Upper and Lower coal beds* have all been opened, and their thicknesses determined. The following section shows the relative positions of the coal beds: (Fig. 44, page 164.)

1. Sandstone and sand shale,		20′	
2. *Coal* horizon, *Kittanning Lower*,		—	
3. Shales and slate,		30′	
4. *Limestone, Clermont, Ferriferous*,		5′	(?)
5. Shale,		16′	
6. Dark gray slate,		14′	
7. *Coal, Clermont, Clarion*,		2′	
8. Sandstone and shale, JOHNSON RUN,		30′	
9. *Coal*,	*Alton Upper*,	1′	3″
10. Slate,			9″
11. *Coal*,			8″
12. Gray and black shale,		14′	
13. *Coal*,	*Alton Lower*,	1′	3″
14. Sandstone,			10″
15. *Coal*,		1′	
16. Hard sandy fire-clay,		2′	
17. Sandstone and conglomerate, KINZUA CREEK,		45′	
18. Shales, *Marshburg Upper*,		10′	
19. Conglomerate and sandstone, OLEAN,		50′	
20. Gray and red shale, MAUCH CHUNK, No. XI,		10′	±
Total,		253′	9″ ±

The *Kittanning Lower coal bed* has been explored for extensively on the Monastery lands, and I am told it has never been found of workable quality and dimensions. Its outcropping level has been located in a number of places. This bed, if ever found of workable size on this tract, would have but little cover and a limited area, because of its high position in the hills.

The *Ferriferous limestone* has been located near the summit of the hill between St. Mary's and the Silver Creek mine; it was "grubbed" for in the loose soil by the farmers,

many years ago; scattered pieces of the stone have been collected in this way and burned into lime. The lime produced was of very limited quantity and poor quality. I am told that all search for pieces of the stone has ceased, since the construction of the Philadelphia and Erie railroad.

The report of the finding and burning of any limestone, in this locality, has been variously accepted and denied by different individuals, claiming a personal knowledge of the facts. I believe there is no question about the authenticity of the report, as it came to me from reliable sources. Those who deny the existence of any *Ferriferous limestone* in this hill, have been influenced in their denial by a preconceived notion that the rocks of the St. Mary's section occupy a much lower position in the coal measures than I have assigned them.

The *Clermont* or *Clarion coal bed* has proved thus far to be the most important bed in the valley of Silver Creek. This is the only locality in Benzinger township, or in fact in Elk county, where this coal bed has been mined; it has been opened in a great many places, and in some instances has been worked by the farmers, in order to obtain fuel for their household use, but from nowhere, except the Silver Creek mine, has coal from this bed been shipped to market by rail.

The mine was worked, under a lease, by Mr. D. Eldridge, and was finally abandoned during the fall of 1879. The bed had become reduced so much in thickness, and the mining had become so unprofitable, that the mine was closed.

The average thickness of the bed was 2 feet. The elevation of the mouth of the mine is 1720 feet above tide.

The following is an analysis of the coal, (A. S. McCreath:)

Water,	.870
Volatile matter,	37.890
Fixed carbon,	52.657
Sulphur,	.838
Ash,	7.745
	100.000
Color of ash,	cream.
Coke, per cent.,	61.240
Fuel ratio,	1: 1.39

The coal has a deep black color, is lustrous, and brittle. No pyrites was observed through the coal. The specimen which was analyzed was composed of numerous pieces of coal, picked from the loaded cars, at the chutes. It was found to contain less sulphur and water than any of the coals analyzed within the four counties. The *Dagus* or *Kittanning Lower coal*, mined near Cameron, contains but .027 of one per cent. more sulphur and only .12 of one per cent. more water than the *Silver Creek coal.*

One of the greatest difficulties encountered in mining this coal was its tendency to *thin out.* Under the eastern end of the Roman Catholic cemetery, the bed was only 7 inches thick, with a heavy sandstone roof. The line along which the bed was found to thin out has a course east south-east and west north-west. All along this line the coal was not more than from 6 to 8 inches thick, while in the mine workings south-west of it, it was everywhere at least 2 feet thick.

Another opening was made on the *Clermont bed* about 150 feet west of the mouth of the mine just described. At the outcrop the bed was 2 feet 6 inches thick; in a very short distance it thinned down to not more than 2 or 3 inches. The dip of the bed, from this latter opening to the mouth of the mine, is about 2 feet to 100 feet, to the north-east.

Both the *Alton coal beds* are opened on the Monastery lands, only a short distance from the *Silver Creek mine.* The *Alton Upper bed* is 30 feet under the *Clermont coal*, and immediately beneath a hard ferruginous sand shale, which marks the bottom of the JOHNSON RUN SANDSTONE. Associated with the coal is found a nodular carbonate of iron ore. The section of the bed is as follows (Fig. 45, page 166):

1. *Coal*,	1′	3″
2. Slate and fire-clay,		9″
3. *Coal*,		8″
4. Fire-clay,	—	
Total,	2′	8″

Fourteen feet below this bed, and separated from it by gray and black, very argillaceous shale, is found the *Alton Lower coal*, in section, as follows (Fig. 46, page 166):

1. *Coal*,	1′	3″
2. Sandstone,		10″
3. *Coal*,	1′	
4. Fire-clay,	—	
Total,	3′	1″

From the fact that the two benches of this coal are separated by a hard sandstone, the bed has locally been called the *Stone coal.*

The succession of the strata forming the lower part of the POTTSVILLE CONGLOMERATE, below the *Alton coal group*, can be better determined in the Silver creek valley, than anywhere else in the vicinity of St. Mary's. The tramway from the mine to the railroad was nearly a mile long, and in that distance it descended 106 feet, from the floor of the drift mouth to the floor of the coal chutes, passing over the *Alton group*, KINZUA CREEK SANDSTONE, *Marshburg shales*, and OLEAN CONGLOMERATE. Many of the individual strata of the sandstone and conglomerate were exposed, when the tramway was first built, so that the dip of the rocks could be measured, and their thickness determined.

No coal was seen here in the Marshburg shales, but a bed was found about 2 miles further west, and north of Scahonda station.

The upper part of the POCONO SANDSTONE is found exposed on the east side of the mouth of Silver creek, at milepost 127, (P. & E. R. R.), and near the Silver Creek coal chutes. The rock consists of a massive gray and greenish gray, fine-grained micaceous sandstone, exhibiting cross bedding, and very much broken up and fractured. Above this rock were found indications of *red shale*, in the interval representing the MAUCH CHUNK SHALES, No. XI.

I regard this section of great importance, for, with others which are given through the report, it establishes the relation between the St. Mary's coal beds and the base of the conglomerate.

Scahonda coal tract.

In the western part of the township, and immediately north of Scahonda station, lie four prongs or fingers of elevated table land, portions of which are underlaid by the two

coal beds of the *Alton group*. They have generally been known as the *Scahonda coal tract or basin*. A glance at the county geological map will show the relative position of this basin. The district lying west and north-west of St. Mary's, between Elk creek and Powers run, was more carefully explored than the summits lying to the north of it, and east of the valley of the East Clarion creek.* This was done, as it was believed the structure of this portion of the county could be better determined by more extended observations made in this section than elsewhere. The conclusions reached here, both as to the structural and systematic geology, were sustained by the more hurried examination made further north. The anticlinal separating the *Fourth* and *Fifth coal basins* is broken in its course through Elk county, as already explained.

To the west of the Scahonda tract the anticlinal seems to be deflected to the west. This fact, taken into consideration with the fact that at St. Mary's the center of the *Fourth coal basin* lies farther to the west, than it does either to the north-east or south-west of the town, accounts, without doubt, for the fact, that on the Scahonda tract there seems to be a greater area underlaid by the *Alton* † *coal beds* than there is either to the north-east or south-west of it.

The elevations of some of the summits seem high enough to include a small area of the *Clermont* or *Clarion coal*, although the outcrop of the bed was not found.

The following section will show the succession of the strata: (Fig. 47, page 164.)

1. Partly concealed, composed principally of hard fine-grained ferruginous sandstone and sand shale, ...	50′
2. *Coal, Alton Upper*, ...	3′
3. Shale and slate, ...	25′

* On some of the Elk county maps, what I have chosen to call East and West Clarion *creeks* have been named East and West Clarion *Rivers*. I believe this is an error. The name River should be applied to that portion of the Clarion waters below the junction of the East and West Clarion branches.

† It would seem to be a matter of very little economical or practical importance what is the extent of territory underlaid by these coal beds, as they have not as yet, been found anywhere of sufficient purity to be profitably mined.

4. *Coal, Alton Lower,*	2′ (?)
5. Sandstone, KINZUA CREEK,	50′
6. Shale and *coal, Marshburg Upper,*	10′
7. Sandstone and conglomerate, OLEAN,	50′
8. Gray shale containing streaks of *coal,*	15′
Total,	205′

There is a perceptible thickening of the JOHNSON RUN SANDSTONE, which caps most of the summits of this tract, west from St. Mary's, where it has an average thickness of only 32 feet. Seven miles due north of the *Scahonda basin*, along the valley of the East Clarion, the sandstone attains its maximum thickness of 80 feet. It is quite possible that the sandstone may have a greater thickness than 50 feet on the Scahonda tract. If such be the case, it would preclude the existence of the *Clermont coal bed* in the western part of Benzinger township.

The summit above Mr. William C. Young's coal opening, on the east side of Scahonda creek, is underlaid by the sandstone, and is 1880 feet above tide.

The elevation of the *Clermont coal bed*, which is on top of the sandstone, at the Silver Creek mine, is only 1720 feet, showing a dip of 160 feet in about $2\frac{1}{4}$ miles, in a direction a little south of east. This is the average dip between the two localities; the local dip of the strata is much greater, as they are subject to a number of rolls between the two places. The coal bed at *Young's opening* dips 1° 45′ north 82° west, whereas the average south-east dip between Young's opening and the Silver Creek mine would only amount to about 45 seconds, and that in an opposite direction to the local dip at the opening.

The JOHNSON RUN SANDSTONE makes a bold escarpment, from the center of warrant 4401, along a line south-west, to the north-eastern corner of warrant 4395. The elevation of the top of the sandstone bluff at the latter point is 2020 feet. This would show a dip of 140 feet in a mile and a quarter, in a direction north of east, toward the Young opening. This is the boldest exposure of rock visited in Benzinger. The stone consists of a hard massive fine-grained sandstone, containing a great deal of ferruginous matter, which segre-

gates along the bed planes. The appearance of the surfaces of the sandstone blocks, perpendicular to the stratification, is very characteristic of the sandstone. Masses of the stone, along the lines of segregation, project beyond the general surface of the rock; these contain great quantities of oxide of iron, and have much the appearance of a siliceous variety of the Clinton fossil iron ore which is found in the Juniata region.

Sometimes the collection of the iron takes place concentrically, about a nucleus of organic matter, or other material which might have a tendency to originate the action; in this case a concretion of iron is formed. The sandstone around the concretion is more rapidly attacked by the atmosphere than the iron ball, which latter falls out, leaving a cavity in the rock. When this occurs, the sandstone resembles very much a conglomerate with the pebbles fallen out.

The *Alton Upper coal bed* has been opened in a number of localities in the western part of the township. Commercially the coal is worthless.

At *Weidenboerner's opening*, near the central part of warrant 4405, the bed consists of a cannelly coal 3 feet thick, at an elevation of 1817 feet. The sandstone above the coal at this point contains numerous plant remains.

On the western side of the summit, between Scahonda and Garner runs, the same bed has been drifted on, at the *Young opening*. The elevation of the bottom of the coal is 1827 feet; the section of the bed being as follows (Fig. 48, page 166):

1. Black slate,	—	
2. *Coal*,	2′	
3. Sandstone,		6″
4. *Coal*,		7″.
5. Fire-clay, (soft,)	1′	
6. Sandstone,	1′	6″
Total,	5′	7″

The sandstone (stratum No. 3), between the two benches of coal, is very hard, has an irregular structure, and contains plant remains. It is subject to changes in thickness; its maximum thickness is 1 foot and minimum 3 inches.

The coal is very slaty and very sulphurous, and, as far as developed at this opening, has produced a worthless fuel. This same bed was developed in a shaft on the same slope of the hill as the Young opening, and to the north-east of it. The coal, at this latter place, was found 3 feet 2 inches thick, was very poor and smutty, but contained no separation, such as was found at the Young opening.

The *Alton Upper bed* was again opened, by a shaft, on the west side of Garner run, to the south of the mouth of Birch run, which flows into it from the west. The bed was slaty and cannelly, and 3 feet thick. The roof was formed of an argillaceous shale, and below the coal was found a black slate and sandstone. The elevation of the coal here is about 1950 feet. The shaft is about two-thirds of a mile north-west of the Young opening.

The outcrop of the *Alton Lower coal bed* was found in a number of places in the western part of the township; its position was estimated to be about 25 feet below the *Alton Upper bed*. The interval between the two beds is composed of argillaceous shale and slate. The lower coal is reported to have been found 2 feet thick. I did not see the face of the coal myself and cannot state its value, but it is very improbable that the bed will ever be found good enough to work. Wherever I have seen the coal in the *Fourth basin*, it is worthless.

There is nothing of interest to note in regard to the lower part of the Scahonda section. The KINZUA CREEK SANDSTONE and OLEAN CONGLOMERATE have a thickness and character similar to that found in other parts of the township.

Between the two rocks, a coal bed from 1 to 2 feet thick has been reported to have been found, representing the *Marshburg Upper or Sharon bed*. Streaks of coal were found underneath the conglomerate, in the gray shale representing the MAUCH CHUNK, No. XI. Still further to the west, in the Ridgway hill, north of the town of the same name, these coal streaks become a bed of coal, which has been opened in the Gresh mine.

St. Mary's to New Flanders.

In the road leading north from St. Mary's, toward the valley of the East Clarion creek, the outcrops of the *Kittanning Lower* and *Clermont coal beds*, were located, by Mr. Sheafer. The former was located a little over a half a mile north of the railroad station, at an elevation of 1805 feet, the summit in the road beyond the outcrop being 1850 feet. The second summit in the road is 1910 feet high; on either side of it, were found outcropping beds of slate and shale, occurring at about the horizon of the *Kittanning Middle coal.* On the north side of this latter summit, the *Kittanning Lower bed* was found outcropping, at an elevation of 1830 feet. But a short distance beyond this point (5 minutes' walk), and 35 feet lower, were seen numerous scattered iron carbonate balls, which bore some resemblance to those from the iron carbonate beds found 1 mile east of the St. Mary's Coal Company's chutes, and representing the *Ferriferous limestone.* (See page 153). It is quite probable that these balls indicate the horizon of the limestone in this locality.

A short distance south of the school-house, which is located about 2¾ miles north of St. Mary's, was found the outcrop of the *Clermont-Clarion coal*, at an elevation of 1780 feet. There is a strongly marked south-east dip at this place. The height of the school-house above tide is 1830 feet. From this point, both the road and the measures rise rapidly, until the summit is reached, about 1 mile north of the school-house, at an elevation of 2200 feet. The summit is apparently capped by KINZUA CREEK SANDSTONE, for just beyond, past the turn in the road, is found exposed, at 2105 feet, 4 feet of the MAUCH CHUNK RED SHALE, No. XI. From this exposure to the stream crossing near S. Getz's house, at an elevation of 1810 feet, are found exposed, at intervals, olive and gray flaggy sandstones, belonging to the POCONO SANDSTONE FORMATION No. X. The average south-east dip of the rocks from this summit to the center of the basin is very great. The distance is nearly 2½ miles, and the total dip is about 500 feet.

There is also quite a perceptible dip from this summit

south-west, in a direction nearly parallel with the axis of the *Fifth anticlinal.*

The elevation of the top of the Olean Conglomerate here is about 2170 feet; on the western edge of the Scahonda tract, 5 miles south-west, it is not over 1970 feet. This rapid dip toward the south-west is caused by the *Kinzua-Emporium anticlinal.*

The elevation of the top of the Olean conglomerate on Jarret's Summit, about 6½ miles north-east of the summit above Getz's, is 2245 feet, showing an aggregate south-west dip between the two summits of 75 feet. Jarret's Summit is directly over the axis of the *Kinzua-Emporium cross anticlinal.* The top of the conglomerate, on the Elk-McKean line, about 6 miles north of this latter summit, is only 2000 feet above tide, which indicates a much greater dip on the north-east side of the axis than on the south-west.

From Getz's, in the valley of Powers run, to New Flanders, in the Clarion valley, the road passes over the outcrop of the Pocono rocks. In the summit of the road, directly north of Getz's, red shale was found, at an elevation of 2135 feet.

The Mauch Chunk No. XI in northern Benzinger is at least 25 feet thick, from actual measurement, and may aggregate as much as 50 feet, which seems to be about the average thickness of the interval generally, throughout the county.

The road crosses Crooked creek about a mile from New Flanders, at an elevation of 1530 feet.

The elevation of the mouth of Johnson run at New Flanders, is 1497 feet.

Chapter X.

Fox Township.

Fox lies to the east of Horton, west of Jay, south of Benzinger, and north of Huston, in Clearfield county, and Horton, in Elk.

The Appalachian divide enters the north-eastern corner of the township; keeps nearly along its eastern border for a distance of two miles, when it turns abruptly to the west, for about the same distance, crossing the Centerville pike about a mile east of Centerville, where it is deflected about S. 25° W., crossing the southern boundary, of the township, about two miles east of the south-western corner.

The ridge which lies along this divide is generally known as Boons mountain: a ridge of considerable height, capped by the Kinzua Creek sandstone and Olean conglomerate, members of the Pottsville No. XII; it is one of the most prominent features in the county. Its height at the road-crossing near Horse Shoe bend, east of Centerville, is 2265 feet, and farther to the south-west, along the road from Kyler's Corners, through the Hollabaugh and Gardiner clearings, to Weedville, the elevation of the summit is 2085 feet.

The area east of the divide is drained by the headwaters of the Wolf lick, Kersey, and Cherry runs, all of which flow into the Bennetts branch of the Susquehanna, within Jay township, and Mill run, flowing into the same branch of the Susquehanna in Clearfield county.

West of the divide, and commencing at the north, the surface of the township is drained by Laurel run, which flows into Elk creek at Scahonda; by Daguscahonda (Mill) run, flowing into the same creek at Daguscahonda; and by Little Toby creek and its branches, the more prominent of which

are Saw Mill run, Meade run, Oyster run, and Brandy Camp creek.

The topography of the township is diversified; and yet, in its main features, it is simpler than that of the other townships in Elk county, with probably the exception of Horton. In a general way, it may be described as consisting of a central trough, having a north-east and south-west direction, included between Boons mountain on the east and what, for convenience of description, may be called Shawmut * mountain, on the west. The details of the topography within this trough are varied, but, in the main, are made up of lateral valleys, drained by the streams coming into the Toby, both on the north-west and south-east sides. The hills between these lateral valleys have an irregular contour, and yet, when viewed from prominent heights, as for instance from the hill immediately south-west of Kyler's Corners, the summit of which has an elevation of 1950 feet, and which commands one of the finest views in the county, they appear very regular in outline. Similar views of the Toby Creek valley, showing the general character of the topography, as I have described it, may be had from several of the summits, near the headwaters of the streams, in the vicinity of the mines of the North-western Mining and Exchange Company.

On the eastern side of Boons mountain, the topography is composed of a number of deeply cut valleys, enclosed by hills of sharp angular profiles. The most prominent of these is probably that through which flows the north-easternmost branch of Kersey run, which heads near the village of Centerville. These valleys, like most throughout north-western Elk county, with the exception of those within the coal basins, are cut out of the softer measures of the Pocono, the hills around them being formed by the outcrop of the members of the Pottsville Conglomerate.

The valleys east of *Boons Mountain anticlinal* are quite

* The mountain or ridge enclosing the Toby Creek and Shawmut coal basins on the west has not, as far as I know, been generally designated by any local name. For convenience of description I have chosen to call this the Shawmut ridge or mountain, from the fact that the old Shawmut railroad was built very nearly along its summit.

different in their outlines from those north-west of the *Shawmut*, *Toby*, and *St. Mary's coal basins*. These valleys are deeper and narrower, and, in consequence, the slopes of the hills are steeper and the topography is more varied, in minute detail, than that to the north-west. This can be best appreciated, by the topographer, in passing over the road from Pistner hill, in Jones, through New Flanders, to St. Mary's in Benzinger, thence to Centerville in Fox, and then south-east to Caledonia in Jay. Between Pistner hill and St. Mary's, a good view is had of the character of the topography, cut out of the formations Nos. X and XII by the waters of the Clarion; and between St. Mary's and Centerville, of similar topography, produced by the erosion of the Elk Creek valley. As soon as Boons mountain is passed, and the descent is commenced to Caledonia or Benezette, a marked difference in the topography is evident.

This difference is a source of great perplexity, in determining the outcrops of the rocks in south-eastern Elk, particularly the members of the POTTSVILLE No. XII; for, the experience gained in the study of the features determined by these same rocks, in north-western Elk, was of little avail in this section of the county. This difference I have attributed to the fact, that the POCONO strata, to the south-east, become more flaggy and more argillaceous, and the alternation of softer beds with the harder ones becomes more frequent, and this formation where it outcrops is more easily eroded. At the same time, the lower part of the POTTSVILLE becomes more massive, the pebbles become larger, and the cement, which unites the particles together, more durable, toward the south-east. It will be readily perceived, that these are just the lithological characteristics to produce such topography, as that which is found. The lower strata in the hills being eroded away more quickly than the cap rocks, of course the valleys will be deep and narrow, and consequently the hills enclosing them will have steep slopes.

The ridge in the vicinity of Centerville, which separates the waters flowing north-west into Elk creek from those flowing south-west into the Toby, has formed an extremely unfortunate barrier to railway construction. The practical

difficulties to be overcome, in the shipment of coal from the extreme north-eastern end of this valley, have been met by the only method which seemed possible, by the North-western Mining and Exchange Company. This is by planes over the hill at the Dagus mines, so as to transport the coal down Daguscahonda (Mill) run to Daguscahonda, (see section page 200), and more recently by a low grade road south-west along the Toby creek, following the tortuous course of this stream and that of the Clarion to Ridgway.

The natural wealth of Fox township lies within the water-shed of the Toby creek and its branches. Here * are located all the coal, which it will be profitable to mine, and the lands which are of any marked agricultural value.

Some of the best farms which I have seen in Elk county are found west of the Toby creek, more particularly along the Brandy Camp and its branches.

The value of the lands here, cannot be entirely attributed to their inherent worth. The industry, economy, and perseverance of the farmers in this section, which struck me more favorably than anywhere else in the county, have unquestionably worked and cared for the farm lands in such a way, as to make them best productive. The rich loam of the prairies, without the exercise of judgment, either in the rotation of the crops, or its enrichment, ultimately becomes poor; and the same might be said, more markedly, of lands such as those in Elk county, the very best of which were, originally, very much inferior to some of the poorer prairie lands.

The greatest heights in the township are along the summit of Boons mountain. The *highest point*, measured, is at the road-crossing between Weedville and Kyler's corners, at an elevation of 2085 feet. The *lowest point* is where the the Toby creek crosses the western line of the township.

Toby Creek coal basin.

Most of the township lies in the *Fourth Bituminous coal*

*Except a very small area in the northern part, drained by Laurel run and Mill run, branches of Elk Creek.

basin, which in Fox township is locally named the *Toby or Toby Creek coal basin*, from the fact that the Toby creek flows very nearly along the center of the basin, its general direction being parallel to that of the axis of the synclinal. On the geological map, (Plate II of the atlas), the center of the basin has not been defined throughout its entire extent in the township. The axis of the synclinal has only been indicated at the points where its location could be absolutely determined, from the dip of the rocks.

It is possible that the *Toby* and *Shawmut basins*, like the *St. Mary's basin* already described, are closed or canoe-shaped basins, and that the south-western end of the latter, and the north-eastern end of the former, pass one another in western Fox. In the north-eastern part of the township, I did not obtain sufficient data to determine the exact position of the center of the *Toby basin*. It is probable, however, that the *Toby* and *St. Mary's basins* may be connected by a line of depression in the strata, the dip of the rocks being toward the line, from either side.

The *Boons Mountain anticlinal* is clearly defined by the topography, and its axis is nearly coincident with the line of greatest height along Boons mountain. A number of explorations have been made here for the coal beds, found both in the Bennetts Branch and Toby Creek valleys, but without success. The general horizontality of the coal beds, in the valleys, has been thought, by many, to prove that they pass under the greater heights of the mountains.

The coal beds, with the low dips which they possess, seem to lie almost in horizontal positions, when exposed over a very small area, yet, when the actual dip is measured, it will be found that the rate of the dip per mile is very considerable, ranging from 50 (0° 33′) to 200 (2° 10′) feet per mile. These dips being much greater, than the average slope of the surface, from the crest of Boons mountain, either north-west or south-east, into the valleys, on either side, would necessitate the coal beds outcropping along the slopes, on either side of the mountain. It is important for those having lands in the vicinity of the *Boons Mountain anticlinal*,

FOX TOWNSHIP.

Fig. 49. p. 185.
Toby Creek Basin vicinity of Centerville and Dagus Mines.

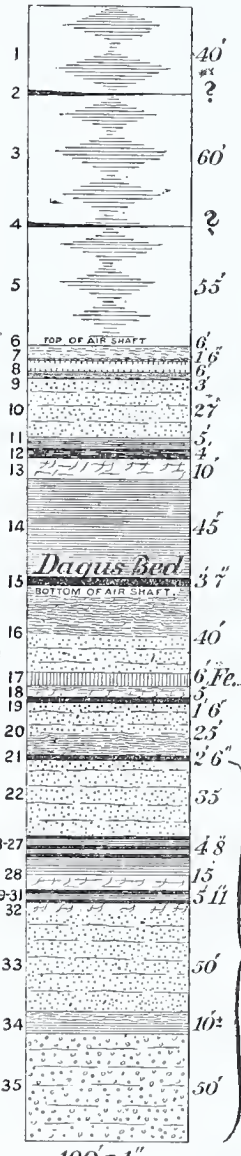


Fig. 53. p. 189.
Alton Coal Group Connor Tract.

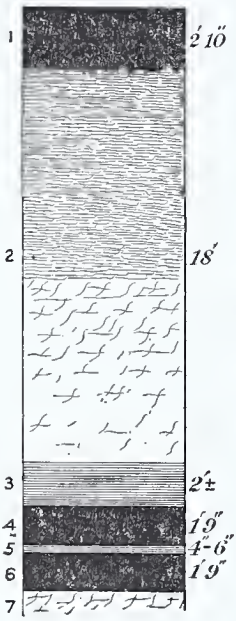


Fig. 51. p. 187.
Upper Alton Bed Connor Tract.

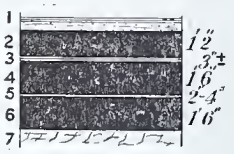


Fig. 52. p. 188.
Upper Alton Bed Connor Tract.

Fig. 50. p. 187.
Lower Alton Bed Connor Tract.

Fig. 58. p. 201. 10' = 1"
Meridith and Taylor Beds Meridith Tract.

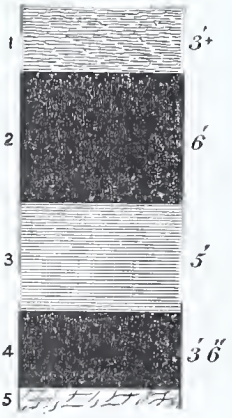


Fig. 54. p. 191.
Lower Kittanning Bed Earley Mine.

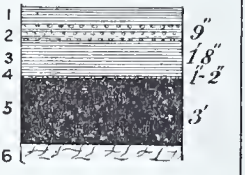


Fig. 56. p. 198.
Middle Kittanning Bed Dagus Mine No 21.

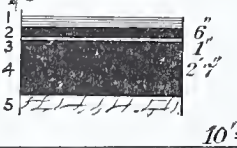


Fig. 57. p. 199.
Middle Kittanning Bed, Dagus Mine D²

10' = 1"

to appreciate this fact, for it is the only true explanation of the failure to find any workable coals in this section.

The *Upper Marshburg bed*, which lies between the OLEAN CONGLOMERATE and the KINZUA CREEK SANDSTONE, might be found to outcrop in many places along the mountain; but, this coal bed is so sporadic in its occurrence, and the quality of the coal, which it contains, is so inferior, that no one could reasonably hope for remunerative returns in its search, even if a 3 or 4 foot bed should be found.

The south-eastern part of the township approaches very nearly to the axis of the *Third coal basin.* Most of the area in this section is immediately underlaid by one of the sandstone members of the POTTSVILLE CONGLOMERATE, and by the shales immediately overlying the *Clermont or Clarion coal bed.* As far as I could learn, no coals of workable dimensions had ever been opened in this corner of the township. It might be possible, however, to find limited areas of either the *Clarion* or *Alton coal beds*, although the quality of the coal which might be expected to be contained, would offer but little encouragement in a search for them. A section of the coal measures obtained at Benezette, and which is placed on the sheet of sections in the atlas, (Plate VII,) shows the *Clarion* and the three *Alton coals*, especially the former and the *Middle Alton bed*, to be of workable dimensions. It would be presumption, however, to conclude that this section could in any way predict, what might be found in the extreme south-eastern corner of Fox township.

The most important area in the township is that which is included within the *Toby Creek basin*, lying between the *Boons Mountain* and *Shawmut anticlinals.* A general idea of the coal measures, in this basin, may be had from the following section, constructed at the head of Coal run, in the vicinity of Mines Nos. 1 and 2 of the North-western Mining and Exchange Company and the Connor mines (Fig. 49, page 184):

1. Interval,	40′
2. *Coal outcrop,*	—
3. Interval,	60′
4. *Coal outcrop,*	—
5. Interval,	55′

Top of air shaft.

6.	Earth and clay,		6′
7.	Sulphur bowlders,		1′ 6″
8.	Loose gray stuff resembling limestone,		6′
9.	Slate and shale,		3′
10.	Hard sandstone,		27′
11.	Slate and sulphur, hard,		5′
12.	*Coal*, slaty and sulphury, (*D bed*,)		4′
13.	Fire-clay,		10′
14.	Slate, black and gray,		45′
15.	*Coal*, (*C bed*,)		3′ 7″
	Bottom of air shaft.		
16.	Shale and sandstone,		40′
17.	*Ferriferous limestone*,		6′
18.	Shale and fire-clay,		5′
19.	*Coal*, (*Ferriferous*,)		1′ to 2′
20.	Sandstone and shale,		25′
21.	*Clermont, Clarion coal bed*,		2′ 6″
22.	JOHNSON RUN SANDSTONE,		35′
23.	*Coal*,	*Alton Upper bed*,	1′ 2″
24.	Black slate,		3″
25.	*Coal*,		1′ 6″
26.	Black slate,		3″
27.	*Coal*,		1′ 6″
28.	Slate and fire-clay,		15′
29.	*Coal*,	*Alton Lower bed*,	1′ 8″
30.	Slate,		3′
31.	*Coal*,		1′ 3″
32.	Fire-clay,		—
33.	KINZUA CREEK SANDSTONE,		50′
34.	Shale and slate,		10′±
35.	OLEAN CONGLOMERATE,		50′±
	Total,		516′±

The only place in the township where the *Alton coal beds* have been practically worked is on the *Peter Connor tract*, in warrant 4077, on Mill run. The elevation of drift No. 2 of the Peter Connor mine is 1875 feet. Both the *Upper* and *Lower beds* were opened and worked here for some time, by Mr. D. Eldridge. The coal was found to be slaty and produced a poor fuel. The beds were subject to many local variations, both as to their thickness and the character of the coal which they contained, and mining was carried on at great risk. The mine is now abandoned. The *Lower bed* was opened in drift No. 1. About 200 feet from the mouth of the mine the following section was measured (Fig. 50, page 184):

1. Gray slate, (roof,)	—
2. *Coal*,	1′ 8″
3. Slate,	2″ to 3″
4. *Coal*,	1′ 3″
5. Hard fire-clay,	—
Total,	3′ 1″ +

The upper bench produced the better coal. Near the bottom of this bench a bony streak was generally encountered from 1 inch to 3 inches thick. The upper surface of the fire-clay underlying the lower bench is very uneven and subject to frequent rolls, faults, and slips, by which the thickness of the coal is materially affected.

In drift No. 2, the *Upper Alton bed* was opened, where a measurement of the bed, made near the face of the mine, gave the following section (Fig. 51, page 184):

1. Slate and sandstone, (roof,)	—
2. *Coal*,	1′ 2″
3. Slate,	3″ ±
4. *Coal*,	1′ 6″
5. Slate,	2″ to 4″
6. *Coal*,	1′ 6″
7. Fire-clay,	—
Total,	4′ 7″ ±

The several parts of this bed, like those of the *Lower Alton*, are subject to frequent and great variations as to their thickness and the character of the coal contained. The roof in this drift was very treacherous. The coal obtained from both of these beds was of a variable character, and was frequently coated with fine clay and iron rust. A singular fact, observed by the miners, was that where the coal benches were thinnest, the coal was rustiest, and where the benches were thickest, the coal was the blackest. In some cases, this can be accounted for, from the fact that the bed is so nearly horizontal, that, where the individual benches are thin, a small closed basin was found, which probably formed a reservoir for the water, filtering from the overlying rocks, which are more or less charged with iron. Where the water did not have a free flow through, or from, the coal, the iron and fine slate, which it would contain, would be deposited in the cracks, existing in the coal, in which it would lie. In some

places the coal was rusty and the bed had a dip sufficient to quickly turn off water, so that the explanation of local basins, would not account for its rusty and dirty character, under these conditions. In this case, it is probable that the water was dammed, by an obstruction in its course, and, in consequence, the iron and clay would be deposited through the coal bed, as before.

The distance between the *Alton beds* on the Connor tract varies from 15 to 18 feet, and the interval is filled by argillaceous shale, slate, or fire-clay. A shaft was sunk to a depth of 19 feet, down to the top of the *Upper coal*; about a quarter of a mile north-east of drift No. 1. The following section of the bed was measured (Fig. 52, page 184):

1.	Sandstone, (roof,)	2′
2.	*Coal*,	1′ 6″
3.	Slate,	2″
4.	*Coal*,	1′ 1″
5.	Fire-clay,	—
	Total,	4′ 9″

The sandstone immediately overlying the bed was ferruginous and very hard, and was overlaid by rotten shale and wash. In the counter drift No. 2, slate is frequently found forming the roof of the bed, and the hard sandstone found in this shaft I believe to be an exception.

Along Laurel run, near the northern line of the township, the same beds were opened and found to be only 12 feet apart. The *Upper* had a thickness of 2 feet 6 inches, and the *Lower* a thickness of 3 feet. These same beds cannot be far below water level at the saw-mill east of J. Moser's house, in warrant 4373. The JOHNSON RUN SANDSTONE, which immediately overlies the *Alton coals*, is found to outcrop in this locality.

Borings have been made by the North-western Mining and Exchange Company near their mines, which have passed through the geological horizons of the *Alton coal beds*. Records of these holes were not kept, but I am informed that no coals representing the *Alton beds* were thought to have been passed through. I do not regard, however, the information reported by the drillers, bearing on this ques-

tion, as sufficiently definite or reliable to base any conclusions, as to the existence or absence of the *Alton beds* under the mines of the North-western Mining and Exchange Company, which are driven in the *Dagus*, "*C*" or *Lower Kittanning coal bed.* It is a matter of little practical importance as to whether these beds do exist here, or whether they are cut out by the roof and floor rocks coming together. Where the existence of the beds has been proven, in the *Toby basin*, they have never been found to contain coal which would make a marketable fuel.

The *Connor mine* was originally opened by Peter Connor in 1866, and has been worked more or less ever since. A section of the strata was measured in the vicinity of the mine in 1877, several years before it was worked by Mr. Eldridge; the measurements were as follows (Fig. 53, page 184):

1. *Alton Upper coal,*		2′	10″
2. Argillaceous slate, shale, and fire-clay,		18′	
3. Black slate, (roof,)		2′±	
4. *Coal,*	*Alton Lower coal,*	1′	9″
5. Black slate,			4″ to 6′
6. *Coal,*		1′	9′
7. Fire-clay, (floor,)		—	
Total,		26′	8″±

I am informed that, prior to the mining of these coals by Mr. Eldridge, the *Lower* one was considered to produce the better coal. In places, the upper bench of this bed becomes bony and sulphurous and has a slight tendency to turn into "*cannel*" *coal.*

The dip of the bed in the mine is variable; the average dip, however, is about 4 feet to the hundred, in a direction S. 14° E. The *Alton Lower bed* was opened by the Kersey Coal Company in 1866, on the western side of the Daguscahonda railroad, about 3.5 miles south of the Philadelphia and Erie railroad. This opening was merely made to test the property; no mining was ever carried on. The opening went in on the dip of the bed, and had to be abandoned on account of water.

The KINZUA CREEK SANDSTONE underlying the *Alton Lower bed* is very coarse and loose-grained, and is stained

with iron, and contains white specks scattered through the body of the rock. Under the action of water it crumbles and deteriorates rapidly. The general characteristics of the KINZUA CREEK SANDSTONE, along Mill creek, are very much the same as those of the rock elsewhere in the county. I was particularly impressed, with the similarity of this rock along Mill creek to that found along Spring creek in Spring Creek township.

The OLEAN CONGLOMERATE along Mill creek contains frequent impressions of calamites. The cement, which holds the pebbles in the body of the rock, is readily decomposed by the atmosphere and gives the surface of the weathered blocks a pitted appearance. The cavities from which the pebbles have fallen, resemble those frequently found in the ORISKANY SANDSTONE, out of which fossil casts have dropped. This similarity is so striking that detached pieces of the OLEAN CONGLOMERATE might readily deceive one, as to the geological horizon from which they came.

The most extensively worked coal bed, and, as far as I have facts to judge from, the most valuable in the township, is the *Lower Kittanning, Dagus, or C coal bed.* It varies from 3 to 4 feet thick, and is generally found from 30 to 50 feet above the *Clermont or Ferriferous limestone.* It has been extensively worked for many years in the vicinity of Earley and Centerville, and is the principal source of supply for the shipments of the North-western Mining and Exchange Co.

The interval between this bed and the *Middle Kittanning or D bed* varies from 50 to 70 feet. In the Dagus air shaft the distance is 55 feet, and in the old Earley mine an interval of 64 feet was found between the top of the *Dagus bed* and the outcrop of the bottom of the *D bed.* The actual vertical distance between these two points, however, in the vicinity of the Earley mine, is probably, at least 70 feet.

The *Dagus bed*, in Fox township, has been considered, by many of the local geologists and the miners, to be a higher geological stratum, than the bed being worked in the vi-

cinity of St. Mary's. That the beds in the *St. Mary's* and *Toby basins* are the same, there can be no doubt. An identity of the bed does not necessarily imply an identity as to the value of the coal, which the bed will produce in different localities.

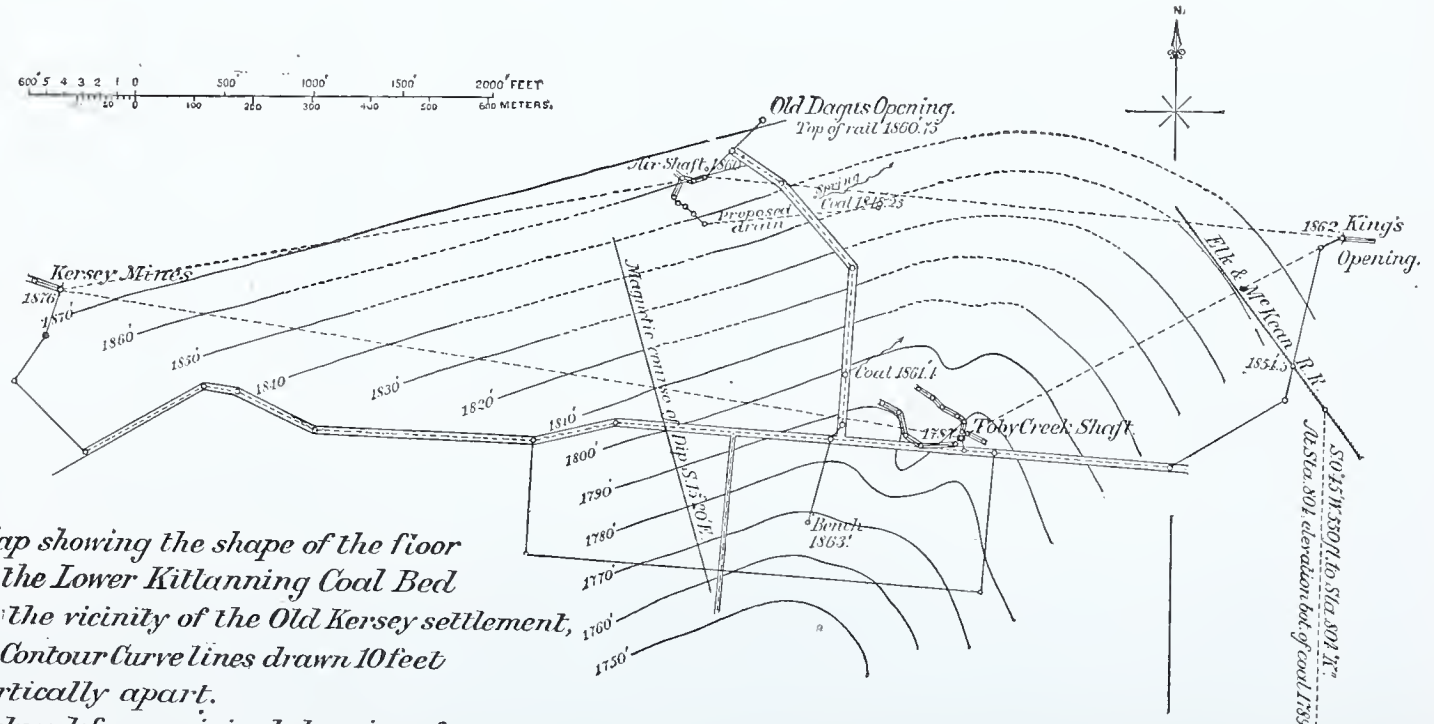
The elevation of the drift mouth at the old Earley mine is 1865 feet. The following section of the bed was measured May 16, 1877, near what was at that time the working face of the mine (Fig. 54, p. 184):

1.	Slate,	—
2.	Carbonate of iron balls and slate,	9″
3.	Black slate,	1′ 8″
4.	Carbonate of iron balls,	1″ to 2″
5.	*Coal*,	3′
6.	Fire-clay, (floor,)	—
	Total,	5′ 6″±

The thickness assigned to the bed, in the above section, is an average for the mine. It is sometimes as low as 2 feet 8 inches thick, and in places has been measured 4 feet in thickness. The coal has a bright luster, and contains sulphur, in flakes, on the surface of the mined blocks. There is no regular seam of slate or bone in the bed, although a little bony coal frequently occurs near the top of the bed, which has to be carefully separated from the coal, before shipment. The course of the butt entries in this mine was S. 87° W. The dip of the bed was 11 feet in a distance of 400 feet, in a direction S. 20° E. There is 70 feet of cover over the Earley mine.

The *Dagus bed* was also opened and worked at the *King mine*, east of the Earley mine. The elevation of the mouth of the King mine is 1880 feet, or about 5 feet higher than the railroad at the lower crossing.

A map, showing the probable structure of the *Toby basin* between the Kersey and King mines, by contour curve lines drawn 10 feet vertically apart, along the floor of the *Lower Kittanning coal bed*, has been reduced from a sketch map, constructed by Mr. E. E. Willard, of Ridgway, and published on page 192. The elevations given on this map have not been reduced to the datum of the levels given in the text. Although it is not known, how definite the informa-



Map showing the shape of the floor of the Lower Kittanning Coal Bed in the vicinity of the Old Kersey settlement, by Contour Curve lines drawn 10 feet vertically apart.
Reduced from original drawing of E. E. Willard, C.E.

tion was, which permitted of the construction of the contours on this map, the facts have certainly been sufficient to delineate the general structure which is indicated. This map is a valuable contribution to the structural geology of the district.

The local dips of the coal bed in the vicinity of the King and Kersey mines are slightly greater than at the Dagus mines (see Plate XII, in pocket of report.)

On Hawk's place, on one of the western head branches of Mill run, and immediately north of the Kersey Coal Company's old settlement, a coal bed was opened by Nathaniel Hyatt, about thirty-five years ago. The same bed was afterwards tested by Hon. C. R. Earley, of Ridgway,* within a distance of 400 feet of Hyatt's opening, and the bed found to be two feet thick on its outcrop. In the upper part of the bed, a streak of bony coal was found, and in the lower part a layer of cannelly coal. Fire-clay forms the floor of the bed, and fine, black and gray slate and sandy shale overlie it. This bed has some of the characteristics of the *Clermont or Clarion*, and outcrops at about the height where it might be expected to be found.

The *Dagus bed* has been opened on the north-eastern side of the road, between the latter opening and Hawk's old house, 79 feet above the *Hawk coal*. The bed was found here to be a few inches over 3 feet in thickness, with carbonate of iron balls in the roof slates.

The actual outcrop of the *Clermont* or *Ferriferous limestone* between these two beds was not found, but a well-marked terrace, out of which springs came, was located about midway between the two coals, which is undoubtedly the horizon of the limestone.

Between 700 and 800 feet, in a direction S. 20° E. from this opening in the *Dagus bed*, is to be found one of the old openings of the Kersey Coal Company, on the same seam. The dip of the bed between these two openings is about 50 feet.

* Dr. Earley's long familiarity with the prospecting, which has been done for coal, for many years, in Elk county, south of the P. & E. R. R., rendered him a valuable guide. Although many of my conclusions do not agree, with the views held by Dr. Earley, the Survey is indebted to him for much valuable information, which he furnished me during my examinations.

The coal in the latter opening had been worked to the outcrop, and the mine had fallen shut, when I visited it in 1877. I am informed that this mine was located by Mr. C. W. H. Eiche, who was afterwards connected with the Shawmut Coal Company. The bed is reported to have been found, of about the same thickness and character as in the Earley mine. Other openings have been made in the *Dagus bed* in the vicinity of Earley and Centerville, which had been all abandoned when I first visited the locality in the Spring of 1877; so that, I found it almost impossible to obtain any reliable information in regard to them. Although considerable territory still exists, in the vicinity of these two settlements and north of the present Dagus mines, which is underlaid by unworked *Lower Kittanning coal*, yet the coal still contained is not sufficient in quantity to support any extensive mining operations, nor is there any area of any considerable extent high enough to give sufficient cover to this bed to insure a desirable coal, if it should be mined.

Numerous outcrops are to be seen along the road between St. Mary's and Centerville. Passing from St. Mary's to the summit, near where the road crosses the line between Benzinger and Fox township, there is observed a strong dip in the measures to the north-west, so that the strata in the vicinity of St. Mary's would be found at a much greater height in this locality.

A coal bed is found to outcrop in the road near the house of W. Weigel, at an elevation of about 1795 feet. It is probable that this coal is the *Upper Alton*, and that the shale and sandstone, which is found above it, is the representative of the Johnson Run rock.

Just beyond the turn of the road at the school-house, in the south-western corner of warrant 4099, another coal bench was located, at an elevation of 1845 feet. This is probably the outcrop of the *Clermont or Clarion bed.* The elevation of the bed is 120 feet below the summit, immediately to the south-east.

In a ravine near J. Week's house a coal bed has been opened, at an elevation of 1880 feet. This bed also is probably the *Clermont.*

In the road near Konse and Shriver's place, to the south of the Week's opening, an outcrop was found, at an elevation of 1915 feet, and in the hill above pieces of limestone were found, which unquestionably came from the broken-down outcrop of the *Clermont or Ferriferous limestone.* The coal outcrop in the road below the limestone is probably that of the *Clermont bed.*

The road crosses two of the head branches of Laurel run, in the northern part of warrant 4098, at elevations of 1760 feet, respectively. Here, large pieces of fine grained sandstone are found scattered along the run, which are probably pieces of the OLEAN CONGLOMERATE, the bottom member of the POTTSVILLE CONGLOMERATE, No. XII.

About half a mile south of this point, at an elevation of about 125 feet higher, a coal outcrop was found, which was underlaid by a gray argillaceous sandstone. Above this coal crop may be found between 30 and 40 feet of shaly sandstone, very much stained with iron. It would appear that the lower sandstone is the representative of the KINZUA CREEK SANDSTONE, the coal the representative of the *Clarion bed*, and the higher sandstone the representative of the JOHNSON RUN SANDSTONE.

The summit along the road in the vicinity of M. Donavan's house, which is about 40 feet higher than the coal outcrop, just referred to, is immediately underlaid by the JOHNSON RUN ROCK. On the road, about a mile to the southwest of where it crosses the head of Laurel run, two coal outcrops were located 10 or 15 feet apart. The upper of these two beds is about 70 feet below the summit at Donavan's, and I take them to be the representatives of the *Alton coals.*

The elevation of the cross-roads, at the school-house, in Irishtown, about a mile north of Centerville, is 1940 feet. About a quarter of a mile north of the cross-roads a coal bed outcrops, which is probably the *Dagus* or *Lower Kittanning bed.*

The correct interpretation of the geological facts which have been obtained, both in the road and along the heads of the streams, between St. Mary's and Centerville, is essential,

in order to explain the relationship between the strata around St. Mary's and those around Centerville.

These facts, which I have depicted here, form but one link in the chain of evidence that would establish the identity of the *St. Mary's coal bed* with that which has been worked at the Earley and Dagus mines. About the only fact which would lead to the conclusion that they are different beds, is that at the St. Mary's mine the elevation of the coal bed is 1775 feet, and at the Earley mine, 1865 feet. The elevation of the bed at the Dagus mine No. 1 is 1815 feet, (See foot note page 197,) 50 feet lower than at Earley. This might naturally be expected, from the fact that the Dagus mine is in the center of the basin, and that there is a considerable upward dip from it to the mines around Earley.

The fact, that the *Dagus bed* at the north-eastern end of the *Toby basin* is so much higher than at St. Mary's, when on general principles we might expect to find it at a much lower level at the former locality, from the fact that there is a general subsidence or sinking of most of the bituminous coal basins to the south-west, would lead to the conclusion, that the *St. Mary's bed* is geologically the lower of the two beds; but the difference of the elevation of the coal beds argues for nothing, when the geological structure of this part of the basin is clearly understood. If they were not the same bed, as is generally supposed, we would expect to find the areas along Laurel run underlaid by the *St. Mary's bed.* That this bed does not exist there, seems to be questioned by no one, who has made explorations along the head waters of this run. The fact is, the strata are very much elevated, along a line at right angles to the general direction of the anticlinals and synclinals passing through Laurel run. In other words, a dome exists in the strata in this portion of the *Fourth Bituminous basin.* The result has been, to give the peculiar canoe shape to the basins, which I have already referred to, and to elevate the higher coal measures, to such a height, that they have been eroded away. This dome in the basin, being nearer Earley than St. Mary's, has necessitated the

Lower Kittanning coal bed being found at a greater elevation in the former locality, than in the latter.

If this structure, which I have defined, did not exist, there is no reason, why most of the higher ground, between St. Mary's and Centerville, should not be as valuable coal lands as those in the vicinity of the St. Mary's and Cascade mines and immediately surrounding the Dagus mines.

North-western Mining and Exchange Co's. Mines.

The most important mining operation which has been carried on in Elk county is that of the North-western Mining and Exchange Company, at the head of Coal run and the head branches of Toby creek. The *Lower Kittanning coal* bed was first opened here by Dr. Earley in 1848. The bed here, and in the vicinity of Earley, has generally been locally designated as the *C bed.* It has an average thickness of 3 feet 6 inches, without any separating bone or slate.

The coal is easily worked, and under the efficient management of Mr. D. Robertson, as superintendent, and Mr. W. A. May, as engineer, a very large percentage of the coal contained, has been mined and shipped to maket.

The bed varies very slightly, either in thickness or the character of the coal contained, where it has been mined from the openings which have been made by this company.

A measurement of the coal, which I made about 500 feet from the mouth of mine No. 1,* of 3 feet 7 inches, may be taken as an average for this mine. (See section, Fig. 55, page 184.) From measurements, made in 1878, I determined the maximum thickness of the bed to be 3 feet 10 inches, and minimum thickness 2 feet 11 inches. The top of the coal is sometimes sulphurous, and occasionally a little bone is found. When such exists, however, it is easily separated from the mined coal and does not necessarily affect the value of the market product.

In mine No. 6 the bed was 3 feet 2 inches thick at the face

*The elevation of mine No. 1. as obtained from several old profiles run from St. Mary's and Ridgway, is 1815 feet. The elevation, recently reported by Mr. W. A. May, is 1792.73 feet. (See Plate XII, in pocket of report.)

November 16, 1883, when I made the measurement; at the mouth of the mine it is 3 feet 6 inches. The upper part of the bed in these workings is sometimes sulphurous, and when this upper layer of poor coal is taken off, there is left on an average about 2 feet 9 inches of good coal.

The bed under the hill, in which the drifts Nos. 6, 7, and 8 are driven, is exceptionally thin. The coal taken from Nos. 7 and 8 is not as good as that taken from No. 6.

At mine No. 3 the bed is 3 feet 4 inches thick, and the gray slate forming the roof resembles very much fire-clay, and contains sulphur balls.

At mine No. 9 the bed is 3 feet 6 inches thick, and at No. 22, 300 feet away, it is 3 feet 2 inches.

At mine No. 20 it is 3 feet 5 inches thick, and the coal taken from this opening was considered to be the best which was being mined during the fall of 1883.

Fifty feet above above mine No. 20 an opening has been made on the *D bed*, at mine No. 21. The section of the *bed* is as follows (Fig. 56, page 184):

1.	Black slate, (roof,)	—
2.	Sulphurous coal, ...	6″
3.	Bony *coal*, ...	1″
4.	*Coal*, ...	2′ 7′
5.	Fire-clay, (floor,)	—
	Total, ...	3′ 2″

At a point 250 feet from where this section was measured, near the opening of the mine, the upper sulphurous portion of the bed is cut out entirely by the lowering of the roof, and the thickness of the coal remaining measures 2 feet 2 inches.

In mine No. 16 the C bed is 3 feet 1 inch thick, 100 feet from the outcrop, and in mine No. 15, about the same distance from the outcrop. it is 2 feet 10 inches thick. Along the face of the hill, in which drifts Nos. 15 and 16 are driven, the bed seems to be thin, but becomes thicker under a heavier cover.

Over mine No. 14, which is opened in the *C bed*, the *D bed* has been opened (mine D2,) with an interval of 50 feet

between them. A section of the *D bed*, measured 150 feet from the mouth, was as follows (Fig. 57, page 184):

1. Black slate, (roof,)	—
2. *Coal*,	8″
3. Slate,	1″
4. *Coal*,	3′ 3″
5. Fire-clay, (floor,)	—
Total,	4′

The same bed has been opened across the run at mine D3.

The roof rock of the *D bed*, in the tunnel over mines Nos. 1 and 2, is not of a constant character. For a distance of 100 yards from the southern end of the tunnel, 3 feet of blue slate was found; whereas, in driving the north end of the tunnel, from below the chutes, through the hill toward mines Nos. 1 and 2, the roof was hard rock from the start.

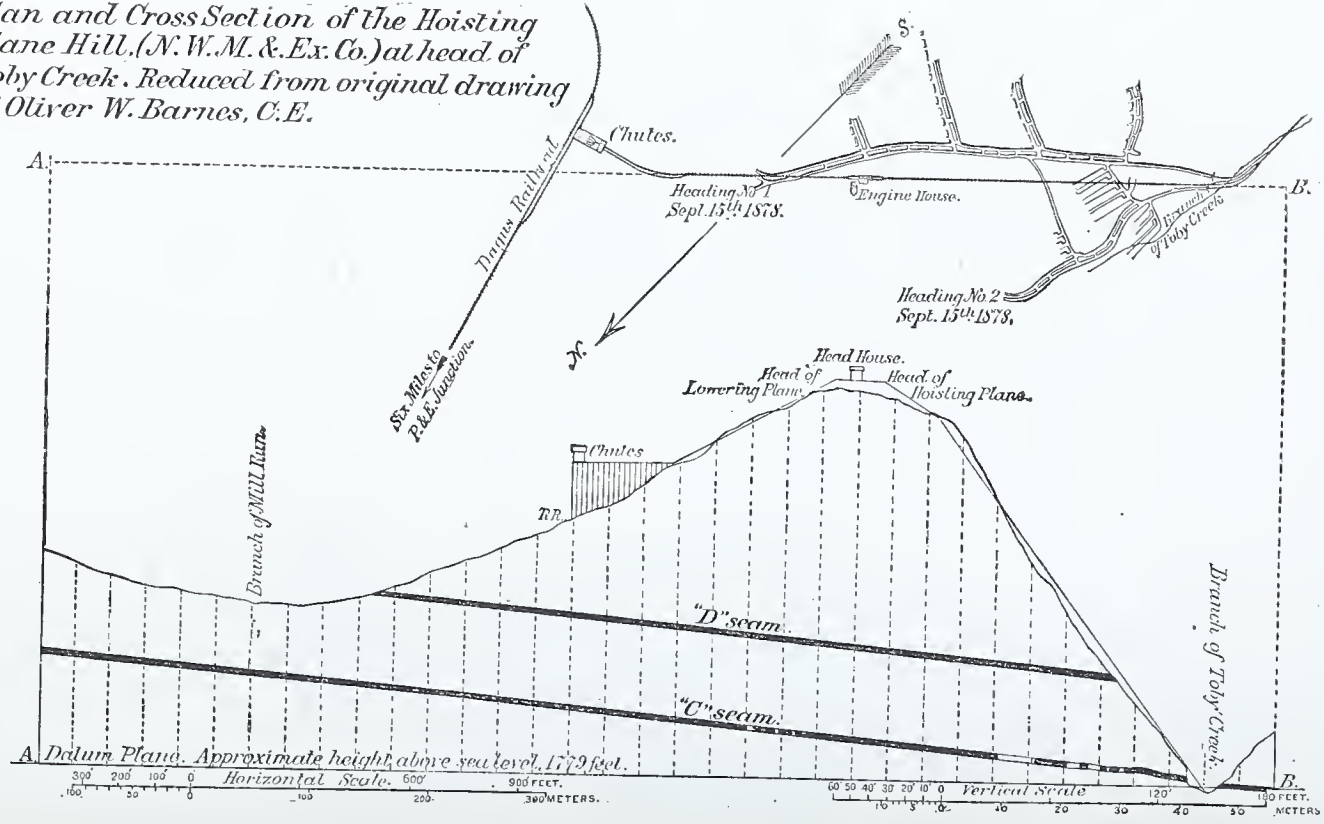
A cross-section of the Dagus Plane hill, constructed by Mr. Oliver W. Barnes, which shows the relative positions of the *C* and *D* coal beds, is published on page 200.

On the western side of the ravine, above mines Nos. 1 and 2, a bed was opened, which has been called the *E bed*, the interval between it and the *D* being 10 or 12 feet. The thickness of the bed was 3 feet 7 inches. Mr. Robertson has spent considerable time and money in exploring for the *E bed*, over mines Nos. 1 and 2.

The existence of a workable coal bed, other than the *D* and *C*, around the mines of the North-western Mining and Exchange Company, has been a question of considerable concern to this company, and diligent search has been made for such a bed. The existence of what has been called the *E bed*, immediately in the vicinity of mines Nos. 1 and 2, has encouraged a careful search for this same coal bed elsewhere. Explorations have been made particularly in the vicinity of the new coal chutes (No. 14), but without success.

On the line between the North-western Mining and Exchange Company's property and the Meredith tract, two coal beds have been opened, which are about 5 feet apart. The opening on the lower seam has been called the *Taylor opening*. Neither of these beds were open so that they

Plan and Cross Section of the Hoisting Plane Hill, (N. W. M. & Ex. Co.) at head of Toby Creek. Reduced from original drawing of Oliver W. Barnes, C.E.



could be measured, at the time that I visited them; a section of the strata, as reported to me, however, was as follows (Fig. 58, page 184):

1. Argillaceous shale, (roof,)	3′+	
2. *Bituminous coal,*	6′	
3. Black slate, (fossiliferous,)	5′	
4. *Cannel coal,*	3′	6″
5. Soft fire-clay, (floor,)	—	
Total,	17′	6″+

The local geologists have called the upper coal of this section the *F bed*, and the lower the *E bed.* I do not feel satisfied as to the true position of these two coal beds in the section. It is not possible to determine the true identity or relationship of these two coal beds, and of the *E* (so called) and *D beds* over the Dagus mines Nos. 1 and 2, without considerable prospecting. It was not possible for the survey to undertake this work, so that I consider the question still an open one.

Wherever I have found it possible to thoroughly make out the structure of this part of the coal measures in Elk county, I have found but two coal beds between the *Ferriferous limestone*, which is exposed in Coal run 40 feet below the *Dagus bed*, and the *Johnstown cement bed.* The lower of these two beds is the *Lower Kittanning*, *Dagus* or *C bed*, and the upper the *Middle Kittanning* or *D bed.* The next bed above the latter is the *Upper Kittanning*, but wherever I have found these latter two beds, they are at a considerable distance apart, 25 to 35 feet, and a hard limestone stratum, from 2 to 5 feet thick, occurs in the interval between them. This relationship is shown on the general section of Horton township. (See sheet of coal sections in the atlas, Plate VII; also Fig. 64, page 226.)

That the D bed, mined in the Dagus mines along Coal run, is the representative of the *Middle Kittanning bed*, there seems to be no question. As to what the so-called *E bed*, overlying the *D* above mines Nos. 1 and 2, is, and why it should not be found above the *D* at other points, particularly in this locality, where it has been explored for,

are questions which cannot be satisfactorily solved, except by the aid of a pick and shovel.

Again, as to what the coal beds at the Taylor and Meredith openings are, I do not feel prepared to say. There are some facts, which I have observed, which would indicate an identity between these two beds and those over mines Nos. 1 and 2; while the characteristics of the former coals, if they have been properly reported to me, would rather lead to a different conclusion.

One of the most important and practical questions to the mining interests, immediately south-west of Centerville, is, what coal beds of workable dimensions are there, and the extent of area under which they can be depended to lie. The explorations which have already been made, in the *C* and *D beds* here, prove them to contain valuable merchantable coals, of a thickness sufficiently great to be economically worked, and sufficiently constant to be depended upon over wide areas. These two beds can, without doubt, meet all demands which will be made upon them, by the Northwestern Mining and Exchange Company, for a number of years; so that, I do not consider it a matter of present concern, as to what other coal beds may exist. I believe, however, that the principal sources of supply, other than the *C* and *D beds*, must be looked for in beds overlying these.*

If the *Clarion* and the *Alton beds* do exist, underneath the *C bed*, in the vicinity of the present Dagus mines, it is hardly probable that they would be of sufficient thickness, or contain coal of sufficient purity, to make them desirable beds for a mining enterprise. This conclusion is based upon observations on these beds elsewhere in the county. Their horizon is below water level at the Dagus mines, and consequently no facts have been obtained, in that locality, which would bear upon the question.

An important fact, bearing upon the identity of the *Dagus bed*, is the outcrop of the *Ferriferous limestone* in Coal run.

*The fact that workable coals are found over the *C* and *D beds* in western Fox and in Horton township would be *sufficient reason* for a hope that they might be found in the *Toby basin*.

The top of the limestone is 40 feet below the *Dagus bed*, as nearly as could be measured. The first outcrop was seen in the bottom of the run 600 feet, in a direction of about S. 10° E., from mine No. 1. At a point about 1000 feet below this outcrop the limestone was found on the right bank of the creek, 10 feet above its surface, at an elevation 35 feet lower than at the outcrop further up the stream. At the latter point the stone was hard, of a bluish gray color, and easily weathered. A thickness of four feet was measured; this, however, is probably not the total thickness of the bed, which, as nearly as could be judged, would approximate nearly six feet.

At the former locality the outcrop of a coal bed (*Ferriferous bed*) was found about five feet underneath the limestone, the interval being filled with shale and fire-clay. The face of the coal was not seen, so that its absolute thickness could not be determined; it would probably, however, range from 1 to 2 feet. The occurrence of a small bed of coal immediately underneath the limestone is not infrequent. A similar coal was found beneath the limestone at General Kane's quarry in the *Johnson Run basin.*

At the lower outcrop on Coal run the limestone was underlaid by 10 feet of gray and blue slate, from which issued an iron-water spring. A coal bed was not found underneath the lower limestone outcrop.

No facts were observed anywhere in the county, which would lead me to suspect that the coal directly under the *Ferriferous limestone* would ever prove a workable bed.

Strata No. 8, in section No. 49, given on page 185, is noted as loose gray stuff resembling limestone, where it was passed through in the Dagus air shaft. This stratum is unquestionably the representative of the *Johnstown cement bed.* The limestone is very argillaceous in its character, and could be easily mistaken for anything but limestone, by any one unfamiliar with its characteristics. A comparison of the Centerville section with the general section of Horton township (see sheet of coal measure sections in the atlas, Plate No. VII) would clearly indicate that this is the representative of the limestone which is found in Hor-

ton, lying midway between the *Middle* and *Upper Kittanning beds*.

The summit of the hill immediately west of Dagus mines Nos. 1 and 2 is about 200 feet higher than the level of the *Dagus bed* at the mines. This hill is sufficiently high to include the *Upper Freeport coal* and *limestone*, the *Freeport Middle* and *Lower coal beds* and *limestone*, and the *Kittanning Upper coal bed*.

As to what, however, might actually be found in the hill, I have no facts to indicate, other than those reported to me by Dr. Earley and Mr. John Dowie, former mining boss, who informed me, in the fall of 1878, that the outcrops of two thin coal beds were found in the positions indicated in the section, the upper being 40 feet and the lower 100 feet below the top of the hill. I was informed that the upper coal bed had been struck in a well on the *Gross farm* near by, and had a thickness of 6 feet; the correctness of this report I am, however, disposed to question.

Other and more recent explorations, which have been made by the North-western Mining and Exchange Co., have failed to disclose the existence of any workable coal beds above the top of their air shaft. Although it would be unsafe to assume that the upper coals in the Horton section existed in the hills around the Dagus mines, yet I know no reason why their representatives should not be found, even if not of workable dimensions. A singular fact, which I have observed in the bituminous coal fields, which may be the result of accident rather than of any fixed natural law, is that seldom are more than two or three workable coal beds found near or immediately above each other, at any locality.

The most definite information which exists, relating to the structure of the *Toby Creek basin*, has been obtained at the mines of the North-western Mining and Exchange Company, at the headwaters of Toby creek.

A topographical map has recently been constructed in the vicinity of these mines by Mr. R. A. Wentworth, under the direction of Mr. W. A. May, which shows, not only the outlines of all the underground workings, but the topog-

raphy of the surface overlying the worked areas. It is published as Plate XII, and is contained in the pocket of this volume.* This map is the most valuable contribution which has yet been made to the local geological structure of any of the *Elk County basins*, and is an evidence of the regularity of the lay of the coal beds.

Although the structure of the *Toby basin* is extremely simple and regular, within the area mapped, it would be unreasonable to assume that a similar structure would be found throughout all the *Elk County basins*, or even through the whole extent of the *Toby Creek basin*. It is sufficient evidence, however, when taken in conjunction with the facts obtained by the Survey and presented in this report, to conclude that the main features of the structure elsewhere, in the *Toby Creek* and *Shawmut basins*, will not be found to differ, to any very great extent, from that in the vicinity of the Dagus mines.

The face of the coal at the Dagus mines has a general direction of north 23° 30′ east, and the butt of the coal bed, which is at right angles to the face, a direction of south 66° 30′ east. The mine chambers or breasts are invariably driven along the face of the coal, and the gangways generally along the butt. In mines Nos. 1, 2, 5, and 11, located north of the Toby creek, the main gangways have been driven along the face of the coal. This has been necessary from the relative position of the mine openings to the dip of the coal, and the area to be mined from them. Where the gangways have not been driven in the direction of the butt or face of the coal, it has been due to local dips, thinning of the bed, or the coal in the bed in special areas becoming faulty and poor. As compared with other sections of the *bituminous coal fields* of the northern part of the State, local squeezes and faulty coal in the Dagus mines are comparatively rare, and local dips here are fewer than might be expected.

A glance at the map will quickly convey to any one, fa-

*This map was not completed until the latter part of September, 1884, too late to be printed in time for publication as one of the plates in the atlas accompanying this report.

miliar with the general methods of bituminous mining, how very free from these special features the *Lower Kittanning bed* at the Dagus mines is, and how constant the bed must be, not only in thickness but in dip, to permit of such regular workings as those defined on this map.

The general direction of the line of no dip, or strike, is south 15° east, and the line of greatest dip would naturally be at right angles to this course.

The elevation of mine No. 1 is 1792.73* feet, and of mine No 20, 1790.6 feet. The latter mine is 3910 feet south 15° 48′ east† of the former, which course is very nearly in the direction of the line of no dip. The elevation of mine No. 19 is 1833.4 feet, and of mine No. 17, 1728.04 feet. The latter mine is 5725 feet south 64° 15′ west of the former; the maximum dip between any two distant points, where the bed has been opened at the mines, is between these two openings, the dip being at an average rate of 1.8 feet to 100 feet.

The structure of the coal measures between Kyler's Corners and Boot Jack, in Ridgway township, but a short distance from the north-western corner of Fox, should be clearly determined by a careful instrumental survey of this portion of the basin. Numerous outcrops of coal beds, of limestone, and of associated shale, slate, and sandstone, are found in the beds of the streams, but, from the fact that very few exposures are to be seen, one immediately over the other, in any one stream, it is difficult to determine the geological horizon of any one outcrop, without first knowing its elevation and the dip of the strata between it and adjacent outcrops. Special localities, in this portion of Fox, where outcrops could be found, were visited at different times, with those living in the township, who might have any knowledge bearing on its geology. Among those from

* The elevations cited here and reported on the map are those reported by Mr. Wentworth and are presumably reduced to the datum of the Philadelphia and Erie railroad, to which all the elevations given in this report have been referred. As to this, however, I have not been definitely informed (see p. 197).

† The magnetic courses and distances between mines Nos. 1 and 20, and mines Nos. 19 and 17, have been protracted from a tracing of the original map furnished the Survey.

whom the most reliable information was obtained in regard to coal openings, was the late Judge Jesse Kyler.

Judge Kyler accompanied the assistants of the First Geological Survey in their examinations in this region, and was not only familiar with what prospecting work had been done, but his knowledge of local geological structure, I have found to be in the main correct. Although Judge Kyler did not presume to know the relationship existing between the outcrops in this portion of Elk county, and those found in other sections of the county or State, yet he had a wonderfully correct idea as to the relationship of local outcrops.

The conclusions which I have arrived at, in regard to the coal measures, I do not consider final, in all cases, from the fact that they are based on barometric elevations and horizontal distances taken from the county map, which, at the time that the work was being done, was all that the State appropriation would permit.

From Kyler's Corners, at an elevation of 1565 feet, to the summit south-west, having an elevation of 1950 feet, the following section was constructed. Although there is a great interval, 175 feet, at the top of the section, whose composition is not known, the structure of the other parts of the section is such as to make it a valuable one for comparison, in other parts of the township (Fig. 59, page 208):

	Hill top, ... 1950 feet above tide.	
1.	Greenish gray sandstone (MAHONING SANDSTONE,) .	20′
2.	Interval, ...	175′
3.	Gray slate and shale, ...	10′
4.	*Middle Kittanning (D) coal bed*, ...	2′(?)
5.	Fire-clay, ...	2′±
6.	Shale and slate, ...	55′
7.	*Lower Kittanning or Dagus (C) coal bed*, ...	3′
8.	Fire-clay, ...	—
9.	Shale and sandstone, ...	50′
10.	*Ferriferous limestone*, ...	6′
11.	Black carbonaceous matter, ...	1′
12.	Gray shale and slate, ...	20′
	Kyler's Corners, ... 1565′	
	Total, ...	344′

The sandstone at the top of this section is probably the representative of the lower part of the MAHONING SANDSTONE. On the summit, are greenish-gray sandstone and

FOX TOWNSHIP.

Fig. 59. p. 207.
Toby Creek Basin
Kyler's Corners.

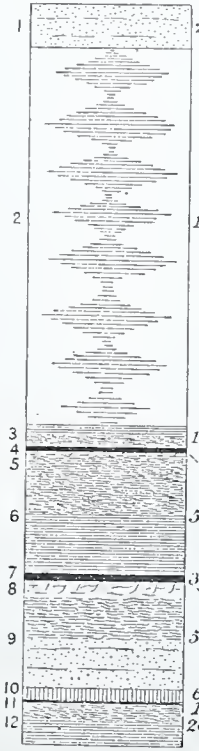


Fig. 62. p. 214.
Toby Creek Basin
Kyler Run.

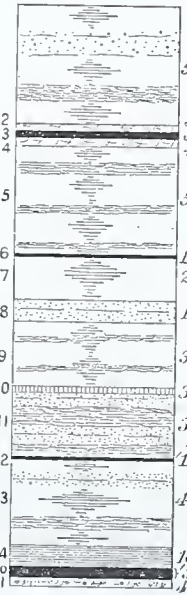
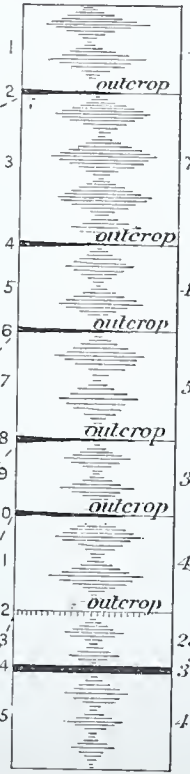


Fig. 63. p. 217.
Toby Creek Basin
Moser Farm.



Upper Freeport Bed.

Lower Freeport Bed.

Upper Kittanning Bed.

Middle Kittanning Bed.

Lower Kittanning Bed.

Ferriferous Limestone.

Clarion Bed.

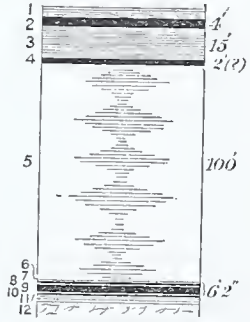
Johnson Run Sandstone,
Top member of No. XII.

Lower Kittanning Bed.

Ferriferous Limestone.

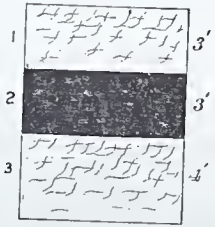
100' = 1"

Fig. 60. p. 211.
Toby Creek Basin
Hayes Run.



100' = 1"

Fig. 61. p. 212.
Kyler's Clay Bed
Kyler Run.



10' = 1'

shale, while scattered around the summit, are to be found a number of blocks of massive coarse-grained, rather friable sandstone, containing flakes of mica and white and black specks, the stone being very ferruginous. The blocks were found within a vertical range of 20 to 25 feet, below the top of the hill. The bottom of the MAHONING is probably 20 feet below the summit.

I was informed by Judge Kyler, who assisted me in the measurement of this section, that no explorations had ever been made, of the interval between the hill-top and the opening on the *D bed*, found at an elevation of 1750 feet. This bed was examined on the outcrop, only, and was found to have a thickness of 2 feet. From the appearance of the bed, however, I should infer that it is probable, that the coal will become thicker, if opened further under the hill. The bed had a roof composed of a gray slate and shale, and a fire-clay floor. The general character of the strata resembles very much that of the strata at *Judge Kyler's mine* and at the *Enos Hayes opening*.

The Lower Kittanning bed was opened by Judge Kyler's son, about 700 feet north-east from the outcrop of the *Ferriferous limestone*, at the point where the stone had been quarried. The coal bed on the outcrop was 2 feet 8 inches thick. It was worked until a thickness of 3 feet could be measured, although, even then, the coal in the bed was not all solid. It would be quite reasonable to infer, from all indications, that this bed will be found of about the same character and thickness as at the Dagus mines.

The *Ferriferous limestone* is exposed on the eastern bank of the Toby creek, about 2000 feet south 70° east from P. W. Hayes' house, near Kyler's Corners. The elevation of the top of the limestone is 1570 feet. The bed is 6 feet thick, and immediately underneath it, is exposed 1 foot of carbonaceous black slate, underlaid by gray shale and slate. The character of the slate under the limestone is the same as that of the slate found outcropping in Coal run below the Dagus mines. No coal bed was found, however, underneath the limestone below Kyler's Corners. The limestone at this point is highly fossiliferous.

Judge Kyler informed me that he never experienced any difficulty in identifying the *Ferriferous limestone* by the character of the underlying slate.

The *Ferriferous limestone* is also exposed in one of the head branches of Saw-Mill run, near the road between Kyler's Corners and Weedville, and about a mile and a half south-east of the former locality. The stone quarried from this bed has been burned by Judge Kyler, and is said to produce a superior lime.

The horizon of the *Clermont* or *Clarion coal bed* should be found from 15 to 20 feet below the surface at Kyler's Corners. There are no facts, however, to warrant the conclusion that the coal bed would be found of workable thickness here, or found at all. As has been said elsewhere, this bed is subject to being cut out by the coming together of the roof and floor rocks, and coal might not be found to exist in this horizon, if shafted or drilled for.

The distance between the lower limestone outcrop, below the Dagus mines, and that just referred to, on the eastern side of Toby creek, below Kyler's Corners, is about 4 miles, in a direction nearly due south-west. The top of the limestone at the latter point is 125 feet below the limestone near the Dagus mines. This would show an average south-western dip along the axis of the basin between the two points of a little over 30 feet to the mile. This fact, and other features connected with the structure of the *Toby basin*, will permit the coal to be mined in the *Toby basin*, south-west of the present Dagus mines, under the most favorable circumstances. No difficulty should be experienced in mining any coal bed above water level, which may be found above the *Ferriferous limestone*, in the Toby Creek valley north-west of Kyler's Corners.

One mile north-west of Kyler's Corners, measured in an air line, and on one of the head branches of Hayes run, which empties into the Toby at P. Hayes' saw-mill, a coal bed has been opened by Enos Hayes, concerning the identity of which there has been a diversity of opinion. It has generally been considered, however, to be one of the three following coal beds: that opened at the *Meredith opening*,

that at the *Taylor opening* east of the Dagus mines,* and the *D bed* opened immediately over the *C bed* at mines Nos. 1 and 2. I am disposed to believe that the *Enos Hayes coal* is the *D* or *Middle Kittanning bed.* Two coal outcrops were found in the run above Hayes' opening, whose positions are indicated in the following section: (Fig. 60, page 208).

1. Slate and shale,	—	
2. Good *coal*, bony *coal*, and black slate,	4′	
3. Slate,	15′	
4. *Coal*,	2′	(?)
5. Interval, lower part, immediately above clay, gray shaly sandstone,	100′	
6. Fire-clay,		2″
7. *Coal*,	1′	3″
8. Sandy fire-clay,		2″ to 5″
9. *Coal*, cannelly,	4′	
10. Slate,		1″
11. *Coal*,		6″
12. Black slate (fossiliferous) and fire-clay,	—	
Total,	127′	2″ +

This bed was opened by Mr. Enos Hayes before the war of the rebellion, and has been worked more or less ever since, for local consumption, by the farmers. The coal bed at this opening seems to have a local dip. At one point where I measured it, the clinometer showed a dip of 3° due north. The elevation of the Hayes opening is 1725 (?) feet, and a little lower than the *D bed* south-west of Kyler's Corners, which was found at an elevation of 1750 feet. The distance between the beds at these two localities is a little over a mile, in a direction a little east of south. The fact that these two coal beds are found at nearly the same height would indicate that the *Hayes bed* was lower than the *D bed* on Toby creek, which flows nearly in the center of the *Toby basin.* I believe, however, that there is a very slight dip in the strata here, due to a break in the general axis of the basin from the *Toby* to the *Shawmut basin.* The connection of these two basins is shown on the geological map (Plate II). From observations made on their out-

*As intimated elsewhere, the *Taylor bed* is probably the *D bed.*

crops between these two points, the strata were found to be so nearly horizontal, that it was impossible to determine whether there was a slight dip to the north-west or to the south-east.

To the east and south-east of Judge Kyler's house the entire series of the LOWER PRODUCTIVE COAL MEASURES is to be found; the highest summits being capped by the MAHONING SANDSTONE, and the outcrop of the JOHNSON RUN SANDSTONE, the upper member of the POTTSVILLE CONGLOMERATE, being found near the saw-mill below Moser's place, about half a mile west of south of Judge Kyler's house. (The Elk geological map, Plate II, is incorrect at this point.)

About 1000 feet south-east of Kyler's house there is a hill about 100 feet higher than the house. The summit of the hill is immediately underlaid by the MAHONING SANDSTONE, which consists of a soft, coarse-grained, flaggy, ferruginous sandstone, containing white and ferruginous specks. The rock on the very top of the hill would appear to be softer than that lower down. At a point 60 feet below the summit of the hill, and about a quarter of a mile south of Kyler's coal mine on Kyler run, a coal bed was opened, which Judge Kyler called the *H* or *Clay bed*. The section is as follows (Fig. 61, page 208):

1. Soft white fire-clay, (roof,)	3′
2. *Coal*,	3′
3. Soft white fire-clay, (floor,)	4′
Total,	10′

This mine was the first one in this locality, which was opened by Judge Kyler, and, at the time that it was worked, produced coal which was popular among the blacksmiths in the vicinity. Coal was shipped from this opening to Ridgway and St. Mary's and as far as Tionesta on the Allegheny River. The fire-clay above this coal is similar to that below it. I believe that this bed is the representative of the *Upper Freeport coal*, which in Horton township consists of two distinct beds, separated by 10 feet of fire-clay and shale. This is the only place in Fox township where this bed has been worked, and so few outcrops of it have

been found that little is known of its characteristics. It would appear, however, that this probably represents the lower bench of the *Upper Freeport coal bed*, in Horton township, and a rider or thin coal bed may be found above it, to represent the upper bench of the same bed, which is 3 feet thick in the latter township.

On the farm of W. Emmet, about half a mile south of Kyler's, a bed has been opened, which measured 2 feet 3 inches thick, with a good roof. Judge Kyler thought that the representative of this bed might be found 15 or 20 feet under his *Clay* or *H bed*. This opening is about 55 feet below the *Clay bed opening*, and I believe it to be the representative of the *Middle Freeport coal bed*.

The sandstone which occurs in the field above the *Emmet opening*, although it resembles very much the sandstone in the hill over the Clay bed opening, I believe to be the *Freeport sandstone*, and not the MAHONING SANDSTONE.

In the well sunk at W. Emmet's house, which at the time I visited it, in November 1878, was occupied by Eber Huntington, a coal bed was struck at a depth of 30 feet from the surface. This is probably the representative of the *Kyler Clay bed*.

At an elevation of 55 feet lower than Kyler's Clay bed opening, and in the ravine above Kyler's later mine, a coal was found, which measured on the outcrop 1 foot thick, with a gray shale exposed in the run above it. This is probably the *Freeport Middle coal bed*, and the same bed as that opened at the Emmet opening. The gray shale which occurs above this 1 foot bed resembles that found in the road just above Judge Kyler's house; the coal bed itself was exposed in a ditch along the road, about 25 feet higher than the house.

Judge Kyler said that he had found chunks of limestone as big as one's fist in the field alongside of the road, above the gray shale overlying this 1 foot bed. These pieces of limestone probably came from the *Freeport Upper limestone*, and if they did, would serve to confirm the structure which I have given to the section. There is one fact, however, which rather tends to weaken my conclusion, and that is, that 30 feet below the outcrop of the 1 foot coal bed in the run

above Kyler's mine, was located the bottom of a flaggy sandstone, which was exposed for a distance of 8 or 10 feet above this point. Wherever I have seen the measures under the *Middle Freeport coal* exposed in the county, they have been composed of soft gray shales, rather than sandstones.

Sixty feet below this bed the outcrop of a limestone was found; the bed is probably 3 feet thick. A limestone, which was thought to be the same as this, was struck in Judge Kyler's well, at a depth of 21 feet, and was 4 feet thick. The limestone is very ferruginous and fossiliferous. Some of it was quarried, but it was difficult to burn, and the lime when obtained slaked with great difficulty. This limestone is probably the representative of the *Freeport Lower limestone.*

The relative positions of the coal beds, and the strata referred to here, are shown in the following section. Although there are a number of gaps in this section, where no information could be had as to the character of the strata filling them, yet the relative positions of the strata, which were exposed, are sufficient I think to support, if not to prove, the interpretation which I have given to the structure (Fig. 62, page 208):

1. Interval, massive sandstone and shale, (MAHONING SANDSTONE,)			55′
2. Fire-clay,			3′
3. *Upper Freeport or Kyler's Clay coal bed,*			3′
4. Fire-clay,			4′
5. Interval, few exposures of gray shale,			50′
6. *Middle Freeport coal bed,* (outcrop,)			1′+
7. Interval,			20′
8. Flaggy sandstone,			10′
9. Interval, few exposures of gray shale,			30′
10. *Lower Freeport limestone,*			3′
11. Gray shale and sandstone,			30′
12. *Upper Kittanning coal bed,* (outcrop,)			1′
13. Interval, few exposures of gray flaggy sandstone and shale,			40′
14. Dark gray slate,			10′
15. *Coal,*	*Middle Kittanning (D) coal bed,*	1′	
16. Bone,			8″
17. *Coal,*			10″
18. Slate,			4″
19. *Coal,*			8″
20. Slate, with streaks of *coal,*		1′	6″
21. Fire-clay containing iron balls,			4′
Total,			269′

The coal bed at the bottom of this section is the coal which has been mined by Judge Kyler, the elevation of the mine being 1775 feet, or 135 feet below Judge Kyler's house.

The *Lower Kittanning bed* was not found in the ravine below the Kyler mine. There is little doubt but that the coal which was worked here is the representative of the *Middle Kittanning*. I was informed by Judge Kyler that, at several places where he had found the outcrop of this same bed, he had found the outcrop of another bed 17 feet above it. I, however, did not find the outcrop of the latter bed at any point, where the outcrop of the other was seen. The run on which Kyler's mine is located flows into the Toby near Jeremiah Hewitt's; this run is not shown on the county map. In descending the run towards the main valley, pieces of limestone were found, which evidently came from the outcrop of the *Ferriferous limestone*.

A section of Kyler's coals is given in the Final Report of the First Survey, Vol. II, p. 543, which, Judge Kyler said, was constructed by Mr. Hodge, of the First Survey, and himself, and was not made from measurement along one hill slope, but compiled from data obtained over a considerable area, in the vicinity of his mines. The relative positions of the strata in this section agree admirably with my observations, although the intervals between the coal beds and limestones differ materially from the measurements which I made.

In Mr. Hodge's section four limestones are shown, which I believe are the representatives of the *Freeport Upper and Freeport Lower limestones*, the *Johnstown Cement bed*, and the *Ferriferous limestone*. The coal beds over his upper limestone, which he reports as 3 feet thick, respectively, and 20 feet apart, are, without doubt, the representatives of the two highest coal beds in the Horton township section, although, as I have said, I have found only one bed in this horizon in Fox township. My failure to find an upper bed does not prove its non-existence, on account of the few exposures found, and the limited time devoted to this survey. Although this coal bed was not seen in north-western

Fox township, it may outcrop in localities well known to those living in the district.

Between Hodge's fourth and third limestones, (numbered from bottom up,) he shows an interval of only 31 feet, with a coal bed immediately over the lower limestone. This interval, I believe, is entirely too small, since, if these two limestones are the representatives of the *Freeport limestones*, the *Middle* and *Lower Freeport coals* should be found between them. So, too, the interval between the third and second limestones, which he represents as 27 feet, has probably a greater thickness, and should be found to contain the *Kittanning Upper coal bed*, if the second limestone is the *Johnstown cement bed*. I did not find either this latter limestone or the *Ferriferous* in the vicinity of Kyler's. The general structure of the lower part of Hodge's section, however, agrees with that published here.

Reference is made to the section contained in the Final Report of the First Survey, from the fact that persons have thrown discredit on the work, because they have not found the section reported by Hodge, at any one locality.

In the vicinity of J. Moser's house, in warrant 4373, considerable prospecting has been done, for a number of years, both by Dr. Earley and the farmers in the neighborhood. Although no actual mining has been carried on here, the outcrops of the coal beds have been determined, sufficiently, to enable me to determine the structure of the section.

At the crossing of the roads, at the point known as Boot Jack, in the south-eastern corner of warrant 4379, in Ridgway township, the elevation is 2166 feet. The surface here is immediately underlaid by one of the sandstone members of the POTTSVILLE CONGLOMERATE, probably the KINZUA CREEK SANDSTONE. The distance from the cross-roads to Kyler's mine is about three miles, in an air line. The dip of the strata between the two points is at the average rate of about 180 feet per mile.

In following the Ridgway and Centerville turnpike from Boot Jack to the intersection of the Brandy Camp road, in the north-eastern part of warrant 4374, in Fox township, a descent of 120 feet is made, the elevation of the forks being

2040 feet. The strata at the latter point, immediately under the cross-roads are, however, very much higher geologically than at Boot Jack. In going south from the school-house, located near these cross-roads, a summit is attained on the Moser farm east of the road, at an elevation of 2060 feet. At the latter point the summit is immediately underlaid by the MAHONING SANDSTONE. The distance between this point and Boot Jack is about two miles and a quarter, in an air line, the direction of which is about S. 21° E. The dip along this line is at the average rate of about 120 feet per mile.

The dip in this portion of the basin is so rapid, that relative heights of the surface serve as very imperfect guides as to the character of the strata underlying it, without a careful allowance being made for the dip of the rocks.

Descending the summit on the Moser farm, to the stream west of J. B. Cuneo's house, the outcrops of 6 different coal beds and one limestone bed were located. At all the points of outcrop considerable digging had been done, and the position of the coal bed, in each case, determined. Sufficient work, however, had not been prosecuted, to enable me to form any opinion as to the thickness of any of the beds, with the exception of the lower one, which has been worked along the outcrop to a considerable extent, by the farmers. The elevations of these coal outcrops have been carefully compared with other outcrops and openings in this vicinity, and I have presumed to define the structure on the Moser farm in the following section, where the elevation of each outcrop is given, and the vertical height of the interval between them. A thickness had been locally assigned to the coal bed at each outcrop, but so little work had been done to actually prove the beds, that I did not care to accept the reports as authentic, and therefore give no indication as to the thickness of the coal bed at each outcrop (Fig. 63, page 208) :

Summit of Moser Hill, 2060 feet.

1. Interval, ... 40′
2. *Upper Freeport coal bed outcrop*, (elevation, 2020′,) . . —
3. Interval, ... 70′
4. *Lower Freeport coal bed outcrop*, (elevation, 1950′,) . . —

5.	Interval,	40′
6.	*Upper Kittanning coal bed outcrop*, (elevation, 1910′,)	—
7.	Interval,	50′
8.	*Middle Kittanning coal bed outcrop*, (elevation, 1860′,)	—
9.	Interval,	35′
10.	*Lower Kittanning coal bed outcrop*, (elevation, 1825′,)	—
11.	Interval,	45′
12.	*Ferriferous limestone outcrop*, (elevation, 1780′,)	—
13.	Interval,	25′
14.	*Clermont and Clarion coal bed*, (elevation, 1755′,)	3′
15.	Interval, JOHNSON RUN SANDSTONE, Creek level, 1710′.	45′
	Total,	353′

As will be observed in this section, there is no mention made of the *Middle Freeport coal bed*, the outcrop of which I did not find. It should have been found somewhere in the 70 feet interval between the two coal beds, found at an elevation of 2020 feet and 1950 feet, respectively. The interval in this section from the *Middle Kittanning bed* up to the *Upper Freeport coal bed* is 160 feet. In the Kyler section the distance between the same two beds is 199 feet. If the identity of these two beds in the two sections is correct, as I have indicated, these measurements show a thickening toward the east, of the strata between these two horizons, on the Kyler and Moser farms.

It is impossible, from the examination which I made in the vicinity of the Moser farm, to report whether any or all of the coal beds shown in the above section are of workable dimensions, or contain marketable coal. These two facts can only be determined by a practical exploration, and by opening the coal beds under the hill, to a sufficient distance from the outcrop, to be sure that the coal is found in a condition unaffected by the natural weathering, near the outcrop. A very important point is gained, however, when it is ascertained that the hills are sufficiently high to take in all the coal beds of the LOWER PRODUCTIVE MEASURES.

The value of this territory, as a mining property, might be estimated from a knowledge of the character and value of the coals which are represented under it, judging from openings made in the same beds in other and adjoining localities. It is not possible, however, to arrive at any final

conclusion on this point from such evidence, as it is a well known fact to coal miners in the *bituminous fields*, especially in this portion of the State, that a coal bed, which is sufficiently thick and contains coal of sufficient value to be profitably mined, in one locality, may thin out and contain very poor coal, in another locality. Attention is called to this, on account of the effort which has been made, in the past, to estimate the amount of coal contained under any property from facts of such a meager character.

A number of limestone and coal bed exposures were found in the vicinity of J. R. Taylor's and Peter W. Thompson's houses, in warrant 4247. Few of these exposures were found immediately one above the other, so that it has been impossible to construct a columnar section of the coal measures, since no reliable data could be obtained here, from which the dip of the rocks could be determined with any exactness.

The identification of the coal beds, which I propose below, can only be accepted provisionally, although it seems to be proved by the facts at present in my possession.

On one of the head branches of McAuley or Kyler run, 800 feet north of J. R. Taylor's house, and at an elevation of 1740 feet, was found a limestone outcrop, which is probably the representative of the *Lower Freeport limestone.* The place of the limestone is probably a few feet above the outcrop, which gave evidence of having fallen down. Mr. Taylor informed me that he had found the outcrop of a coal bed just below his barn, at a point where a spring is located. The elevation here is 1790 feet, and the coal is probably the representative of the *Middle Kittanning.*

The elevation of Mr. Taylor's house is 1855 feet. The rock immediately underlying it appears to be sandstone. A coal bed was found on the western side of Kyler run, at an elevation 1645 feet. The bed was 1 foot 6 inches thick, and the coal had a cannelly structure and was hard and bright. The roof, 6 feet of which was exposed, consisted of gray and black slate, containing iron balls. The bed has been worked by the farmers along the line of outcrop for a distance of about 200 feet, in a direction nearly

north and south. There appears to be a slight dip in the bed to the north-east. This dip, and the north dip at the Enos Hayes opening, may be local, and if so, it is a striking fact that both dips should be in the same direction. If all the strata in the vicinity of these two coal openings have a general north or north-east dip, the interpretation which I have given to the structure may have to be considerably modified. The coal bed at the Kyler run opening is probably the representative of the *Lower Kittanning, Dagus, or C bed.*

On one of the head branches of McAuley run, immediately above Peter Thompson's, the outcrop of a coal bed was located, at an elevation of 1725 feet. The face of the coal was not seen, but Mr. Thompson, who had worked it, reported its thickness to be 4 feet. This bed is probably the same as that mined along the outcrop just referred to.

At a point 60 feet above this bed, the outcrop of a hard siliceous gray limestone 4 feet thick, underlaid by gray shale, was located. The stone from this bed is very tough and hard to break, and possesses many characteristics of the *Johnstown cement bed*, of which it is probably the representative; 15 feet above the limestone the outcrop of a coal bed was found, whose thickness is unknown. It was measured on the outcrop, but the full face of the coal was evidently not seen. The elevation of this outcrop was 1805 feet. The bed is probably the *Kittanning Upper coat.*

The elevation of Mr. Thompson's house is 1910 feet, and at a depth of 40 feet, in the well adjoining the house, a bed was passed through, which measured 2 feet 6 inches in thickness, with fire-clay underlying it, which formed the bottom of the well. This bed would appear to be the *Middte Freeport.*

A bed of cannelly coal was opened, by Mr. Taylor, on the head waters of Brandy Camp creek, about a quarter of a mile west of his house. This bed was reported to be 4 feet thick. Mr. Taylor says that a bed was found 16 feet below this coal, which measured 2 feet on the outcrop. He regarded the cannel coal to be the same as the bed south-east of his house, at an elevation of 1725 feet, referred to above.

The outcrops on the Brandy Camp were not visited by me. If the coals in warrant 4247 have been correctly identified, there is a considerable dip to the south-east, between Moser's and Taylor's farms.

Bog Iron Ore.

At the junction of the roads north of Moser's, and about one mile due west of Kyler's, a deposit of *bog iron ore* exists. This bed was examined by Mr. Hodge, and a description of it is contained in the Final Report of the First Survey (Vol. II, p. 542).

"A large deposit of red bog-ore occurs on the land of Mr. Thompson near the head of Brandy Camp, adjacent to the conglomerate, and seems to be connected with filtration through the body either of this rock or of one of the ferruginous sandstones above it. Though no satisfactory exposures of Seral conglomerate were here seen near the level of the ore, the stratum was detected in the bed of the stream, at a somewhat lower level, 1 mile lower down the Brandy Camp, and 20 rods beyond was seen a bed of limestone in the edge of the creek, and over it about 40 feet of dark-colored shale. This shale, in other localities, was discovered to abound in kidney-ore, and the deposit in question might by some be referred to it, but I more incline to attribute it to the sources above adverted to. It covers in all an extent of perhaps 10 acres, and was proved in one place to be 7 feet deep, though its average depth is believed to be not so much."

Mr. Hodge, in explaining the occurrence of this ore, I believe is right, in referring its origin to the filtration through the sandstone found in its vicinity, which is the representative of the JOHNSON RUN SANDSTONE, the top member of the POTTSVILLE (SERAL) CONGLOMERATE. This sandstone is very ferruginous in places, and when the individual grains forming the body of the stone are loosely cemented together, it rapidly deteriorates, and the iron which is found in the rock is easily washed out and subsequently deposited, forming a bog-ore.

Other bog iron ores are found in Elk county, and refer-

ence is made elsewhere to two of the most prominent deposits, one in Spring Creek township and one in Ridgway township. It is probable that a great many deposits will be nncovered in the county, in areas which are not now suspected to contain them. No deposit, however, has been found, as yet, in the county sufficiently rich in iron to make it profitable to work it, either for local consumption or for shipment to distant furnaces. All of these bog-ores are highly siliceous and argillaceous, and, if nsed at all for the manufacture of iron, they can only be utilized as a mixing ore. Even then the ores would certainly have to be washed and carefully prepared, which would make them too expensive, before reaching the furnace stack.

Chapter XI.

Horton Township.

Horton is the extreme southern township of the county. To the west of it lies Spring Creek township, Elk county; Snyder township, Jefferson county, bounds it on the west and on part of the south; Huston township, Clearfield county, lies to the south of the eastern portion and to the east of the southern portion. To the east of the northern portion lies Fox, and to north of it Ridgway and Fox.

The entire township, with the exception of a small area along its northern boundary, is drained by Toby creek, which empties into the Clarion River 8 miles, measured along the water course, from Ridgway.

The topography is broken and irregular. Most of the township is underlaid either by the strata of the Lower Productive coal measures or Pottsville conglomerate No. XII.* On this account the general level of its surface is comparatively high.

The highest elevation, which I measured in the township, is 1900 feet above tide. This is the height of the summit immediately west of George Faust's house. The conglomerate summits in the western part, along the *Fourth anticlinal axis*, rise to a much greater height, or about that of Boot Jack, at the road-forks in warrant 4389, in the southeastern corner of Ridgway township, which is 2166 feet above tide level. The lowest point in Horton is where Toby creek crosses its western boundary and enters Jefferson county, at a height above ocean of 1442 feet.†

*The Lower Productive coal measures in Elk county, I have chosen to extend down into the Pottsville conglomerate series, as will be explained in the description of the general rock sections, (See Report RR, Part I).

†This is the elevation given of County Line run at County Line, on Little Toby creek, 1¼ miles above Brockwayville. This elevation is based on the height of the bench-mark at the north end of Clarion bridge pier, Ridgway, which, according to Mr. Oliver W. Barnes, is 1357 feet. To reduce this to the datum of the P. & E. R. R. 21.8 feet should be added, which would make the elevation of the county line (1442+21.8) 1463 8 feet.

The township lies almost entirely within the *Fourth bituminous coal basin*. The *Ridgway* (*Fourth*) *anticlinal axis* crosses the northwestern part of the township, and the *Boon's Mountain* (*Third*) *anticlinal axis* the southeastern corner.

The center of the *Fourth basin* does not lie along a continuous straight line through Elk county; the general direction of the synclinal axis is broken, and there are formed within the main basin the *St. Mary's sub-basin*, the *Dagus* or *Toby sub-basin*, and the *Shawmut* or *Meade Run sub-basin*.

The *Toby basin* ends in the vicinity of the junction of the Little Toby and Brandy Camp creeks, along the Horton-Fox township line. The axis of the *Meade Run basin* enters Jefferson county at the angle made by the southern and western boundary lines of Horton township. The northeastern end of this basin is near the junction of the Brandy Camp creek and Karns run. (See Atlas Plate 2.)

The discovery, that the axis of the *Fourth basin* in Elk county does not lie along a continuous straight line, is of great importance to Horton township, since it establishes the fact that that portion of the axis in this township lies much farther west than has been generally supposed, and consequently the area which is underlaid by the productive coal measures is greater than has been credited to this township. This, together with the fact that the *Meade Run basin* is a comparatively deep synclinal along its axis, makes Horton the leading township in the county, as far as the amount of coal which it contains is concerned.

The failures attending the operations of the Shawmut Coal Company, aside from the management of its affairs, were due to the fact that the two lowest workable coal beds in the series (*Lower Kittaning* (?) *and Clarion*.) were opened on the rim of the *Meade Run basin*, in the worst locality which could have been selected for a profitable mining operation. The *Lower Freeport bed*, which no doubt contains the best coal, was never mined.

A number of barometric heights were determined in Horton township, which are based upon the elevation of the

old Shawmut and Ridgway R. R. at Shawmut mine. No. 8 on Meade run, which is 1621 feet above tide, and upon the elevation of the level of water in Toby creek at the county line crossing, which is (1442 plus 21.8) 1463.8 feet; these elevations are supposed to be based upon the datum of the final profile of the Phila. & Erie R. R., as published in Report R. The elevations taken by barometer have been subjected to numerous checks and are approximately correct. Although many of these elevations are scattered, a study of them will aid much in a clear understanding of the topography and geology of the township.

Hyde House, Ridgway,	1400 feet.
P. & E. R. R., "	1393 "
S. & R. R. R. crossing Ridgway and Centerville road,	1925 "
Lower Kittanning (?) *bed* at mine No. 8,	1605 "
Lower Kittanning (?) *bed* at mine No. 15,	1845 "
Lower Kittanning bed, McAllister's farm,	1600 "
Road at J. C. McAllister's,	1580 "
Clarion bed at mine No. 7,	1685 "
Clarion bed at mine No. 16,	1735 "
Boot Jack,	2166 "
Road forks, warrant 4248,	1760 "
Road at Brandy Camp Hotel,	1565 "
Lower Freeport bed, ("M vein"), Faust farm,	1760 "
" " " " west side of Meade run, north of Meade Run school-house,	1710 "
Lower Freeport bed, ("M vein"), tunnel opening southwest of Meade run school-house,	1650 "
Freeport Lower limestone, McAllister farm,	1740 "
Ferriferous limestone, mouth of Karns run,	1535 "
George Faust's house,	1765 "
J. C. Wellington's house, Karns run,	1600 "
Meade run (Colomo) school-house,	1550 "
Theodore Fox's house,	1530 "
Summit of Fox hill,	1755 "
Freeport Lower limestone, west of Fox hill,	1580 "
Bottom bench of *Freeport Upper coal*, west of Fox hill,	1650 "
J. S. Chamberlain's house,	1545 "
Summit of Chamberlain hill,	1845 "
Freeport Lower limestone, Chamberlain hill,	1730 "
Ferriferous limestone, Chamberlain hill,	1585 "
Brockport,	1545 "

The total thickness of strata exposed above water level in the township is 787 feet, sub-grouped as follows:

LOWER PRODUCTIVE COAL MEASURES including the MAHONING SANDSTONE,	392′
POTTSVILLE CONGLOMERATE, No. XII,	185′

Sections in Meade Run Coal Basin.

100' = 1"

Fig. 64.
General Section.

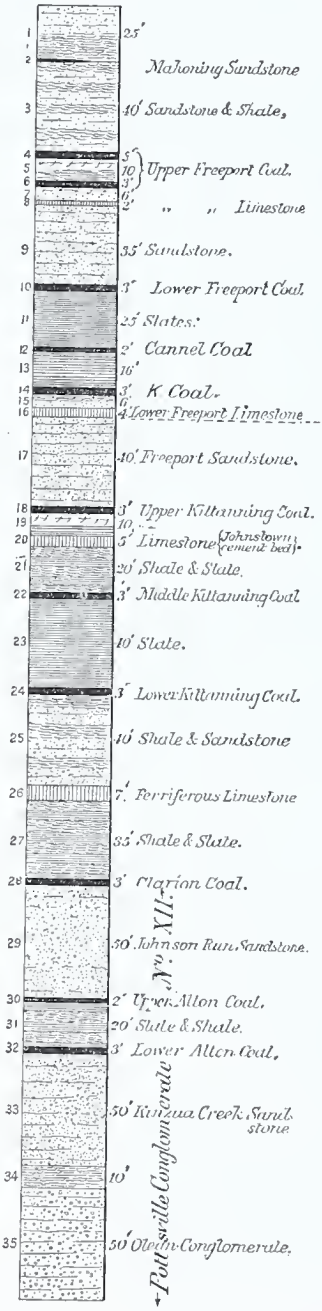


Fig. 65.
Mc Allister Farm.
Warrant 4249.

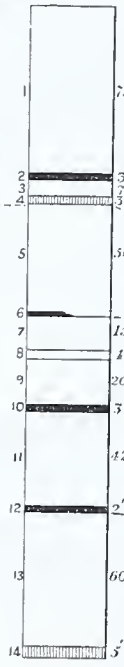


Fig. 66.
Vicinity of Shawmut Mine No. 8.

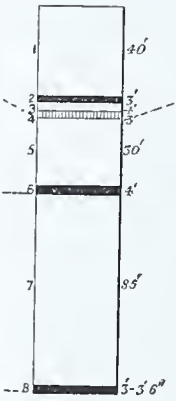


Fig. 67.
Fox Farm
Warrant 4400.

The structure of the coal measures below the bottoms of Sections Nos. 66, 67 and 68, may be presumed to be, in a general way, the same as that shown in Section No. 64.

O.B.H.

MAUCH CHUNK SHALE, (RED,) No. XI,	10′
POCONO SHALES AND SANDSTONES, No. X,	200′+
Total,	787′

The following section, which is general for Horton township, and which may be said to represent the average thicknesses of the rocks, has been compiled from the individual sections measured throughout the township, (Fig. 64, page 226):

1. Sandstone and shale,	25′	
2. *Coal* outcrop (*"P vein"*),		MAHONING SANDSTONE, 65′
3. Sandstone and shale,	40′	
4. *Coal (" O vein") Top bench Freeport Upper coal,*		3′
5. Fire-clay and shale,		10′
6. *Coal (" N vein") Bottom bench Freeport Upper coal,*		3′
7. Fire-clay and sandstone,		6′
8. *Freeport Upper limestone,*		2′
9. Slaty sandstone,		35′
10. *Coal (" M vein") Freeport Lower coal,*		3′ to 4′
11. Soft gray slates,		25′
12. *Coal, cannel (" L vein"),*		2′
13. Gray slate,		16′
14. *Coal (" K vein"),*		3′
15. Shale and sandstone,		6′
16. *Freeport Lower limestone,*		4′
17. Flaggy sandstone and slate, *Freeport sandstone,*		40′
18. *Coal (" I vein") Kittanning Upper coal,*		3′
19. Fire-clay and slate,		10′
20. *Limestone, Johnstown Cement bed,*		5′
21. Shale and slate,		20′
22. *Coal (" H vein") Kittanning Middle coal,*		3′
23. Black and gray slate,		40′
24. *Coal, Kittanning Lower coal,*		3′
25. Shale and sandstone containing an occasional *coal* seam,		40′
26. *Ferriferous limestone,*		7′
27. Shale and sandstone,		35′
28. *Coal (" C vein") Clarion coal,*		3′
29. Sandstone and shale, JOHNSON RUN SANDSTONE,		50′
30. *Coal (" B vein") Alton Upper coal,*		2′
31. Slate and shale,		20′
32. *Coal (" A vein") Alton Lower coal,*		3′
33. KINZUA CREEK SANDSTONE,		50′
34. Marshburg shale,		10′
35. OLEAN SANDSTONE AND CONGLOMERATE,		50′
36. MAUCH CHUNK SHALE (RED), No. XI,		10′
37. POCONO SHALES AND SANDSTONES, No. X,		200′+
Total,		787+

The nomenclature of the coal beds of the northern counties of Pennsylvania has always been in the greatest confusion, and the system of naming the individual beds, which has been generally employed in the Allegheny valley, has never been *properly* applied to the Elk county section. During the survey of McKean county, and until I had connected my work with that done by other Survey assistants to the west and south, provisional names were adopted for the coal beds described in Report R on McKean county. Some of these names have now been abandoned, because the identity of the *Freeport*, *Kittanning*, and *Clarion coal groups* in Elk county has been finally established.

The relative positions of the coal beds in the *Meade Run basin* are exhibited by the general section of the coal measures in Horton township (Fig. 64) and detail sections in special localities given on pages 226 and 230. Sections Nos. 68, 69 and 71 were constructed from measurements obtained from instrumental surveys and test openings made in the coal beds and reported to me by Mr. Eiche, and sections Nos. 65, 66, 67, 70 (same as 66), 72 and 73 were constructed from repeated examinations and measurements made by Mr. Sheafer and myself. There is no doubt, as to the existence, in the *Meade Run basin*, of the individual coal beds of the general section (Fig. 64) or of the relationship indicated between the coal beds of the other sections, although the correctness of the conclusions stated in this report have been repeatedly questioned by local geologists, not only in Elk but in Jefferson and Clearfield counties, whose opinions as to the geological structure of localities where personal examinations have been made are worthy of the highest consideration. Erroneous views are held by many who have made hurried examinations of the *Meade Run basin* and who lack a sufficient number of definitely connected facts. The conclusions stated in this report have been based upon facts obtained during numerous careful examinations extending over a period of nine years.

The local alphabetic names used by the Shawmut Coal Company have been placed alongside of the names, which are more generally known throughout western Pennsylvania.

The highest geological stratum measured in the township was the MAHONING SANDSTONE, which caps the hill west of Theodore Fox's house about ¾ of a mile above Little Toby creek, in warrant 4400. As nearly as could be determined, the center of the *Meade run basin* is not far from this point. The top of the hill is 1755 feet above tide.

The top of the hill immediately west of George Faust's house is 1900 feet high and is also underlaid by the MAHONING SANDSTONE. The rock is found at a higher level on this hill, as it is not so near the center of the *coal basin* as the Fox hill.

The same sandstone caps most of the higher summits, along either side of the valleys of Meade, Oyster, and Johnson runs, so that there is a very large area of the *Meade Run basin* which is underlaid by *all* the coal beds and associated strata of the general section.

The MAHONING SANDSTONE consists of a gray and yellowish flaggy sandstone and shale. The shale is generally very argillaceous and alternates every 10 or 15 feet with the more massive sandstone beds. Its thickness in the township is possibly as great as 100 feet.

About the center of the sandstone and shale the outcrop of a thin coal bed was found in several localities. This bed is locally known as the "*P vein.*" It has no general name in Western Pennsylvania, since its occurrence is local. Its outcrop was located at the head of Worrall run, about 150 feet west of opening No. 14, made on the top bench of the *Upper Freeport bed*, and at an elevation above tide of 1850 feet. Another outcrop of the same bed was located in the hill above the tunnel driven through the bottom bench of the *Upper Freeport coal bed*, in warrant 4369, between Faust run and North run. This bed is but a few inches thick, has never been regularly opened, and is not considered to be workable. The interval between this coal and the *Upper Freeport bed* is from 35 to 40 feet.

The *Upper Freeport coal bed* in the *Meade Run basin* is frequently composed of two distinct beds, separated by a stratum of fire clay or argillaceous shale from 6 to 12 feet thick. On Worrall run, which is a branch of Johnson run,

Sections in Meade Run Coal Basin.

40′ = 1″

Fig. 68.
Worral Run.
Warrant 4344.

Fig. 69.
North Run.
Warrant 4344.

Fig. 70.
Meade Run
Warrant 4344.

Fig. 71.
Vicinity of
Meade Run S.H.
Warrant 4343.

Fig. 72.
Hyde Farm
Warrant 4396.

Fig. 73.
Horton Run
Warrant 4255.

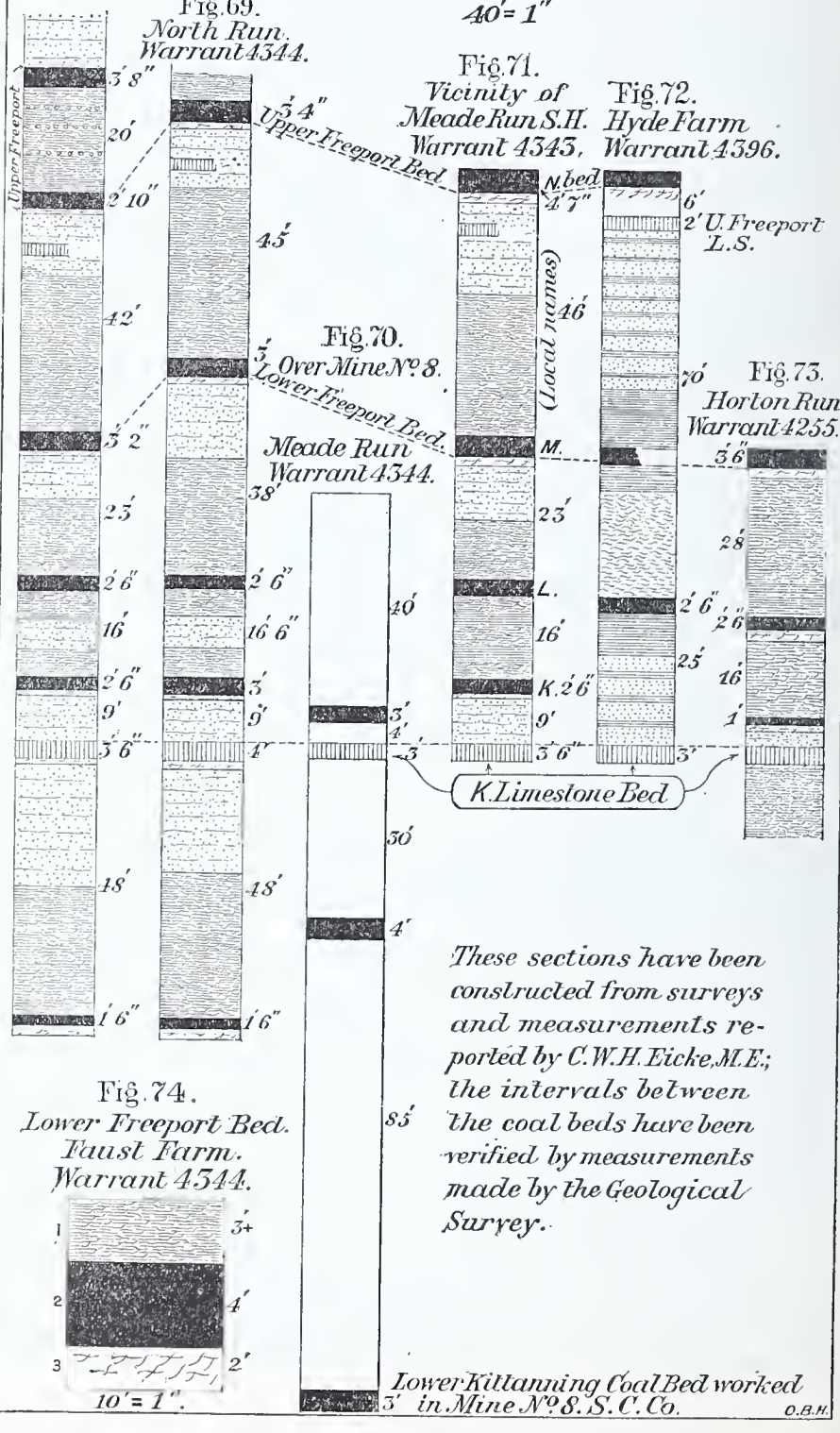


Fig. 74.
Lower Freeport Bed.
Faust Farm.
Warrant 4344.

Mr. C. W. H. Eiche, mining engineer in the employ of the Shawmut Coal Company, reports that these two coal benches are 20 feet apart, being separated by argillaceous shale containing nodules of iron ore. The average thickness of each bed is reported to be 3 feet.*

The top bench ("*O vein*") was opened at opening No. 4 of the Shawmut Coal Company, on warrant 4344, the thickness of the bed being reported to be 4 feet.

The bottom bench("*N vein*") has been opened at opening No. 4 on the Faust farm, elevation 1815 feet, and at opening No. 13 immediately under No. 14, at the head of Worrall run, elevation 1800 feet. At No. 13 the following section is reported:

1.	Shale.	
2.	Gray slate,	2 9
3.	Sandstone, flaggy,	3
4.	*Coal*,	3
5.	Fire clay,	2
	Total,	10 9

At opening No. 4 a tunnel was driven into the bed through the hill, the elevation of the western end of the tunnel being 1825 feet, and of the eastern end, 1815 feet, the dip of the bed being to the south-east. The thickness of the bed in the tunnel is reported to be from 3 feet to 3 feet 6 inches.

Sufficient openings have not been made on this bed throughout the *Meade run basin* to conclude that the bed always exists in two distinct benches. On Coal run, west of Theodore Fox's, warrant 4400, it apparently exists as one solid bench of coal, with a reported thickness of 6 feet; the elevation of the bed is 1650 feet.

The Freeport Upper limestone underlies the coal bed, with an interval between of from 5 to 10 feet, generally

*Very few of the coal beds in Horton township have been opened so that they can be examined and their thickness measured. The thicknesses which are assigned to the several beds in this report have been reported by men who have worked in the mines. In most cases I have given the lowest measurements which have been reported to me. Most of the property reports relating to coal areas in Elk county, which have been published, contain exaggerated statements in regard to the coal bed thicknesses.

filled by fire-clay,* sometimes by shale, and rarely by sandstone. But few outcrops of this limestone were seen. Back of the hotel on J. S. Hyde's farm, on Toby creek, an exposure of this limestone was found at an elevation of 1980 feet, as determined by Mr. Sheafer, the bed being 2 feet thick and composed of a bluish gray, rather coarse grained, brittle limestone, with an irregular fracture. Specimens collected from this bed gave the following analysis (A. S. McCreath):

Carbonate of lime,	80.357
Carbonate of magnesia,	1.619
Oxide of iron and alumina,	3.610
Phosphorus,	.086
Insoluble residue,	12.290

The limestone is sometimes so argillaceous that it is hard to distinguish it from shale, by which, at times, it seems to be completely replaced.

The *Lower Freeport coal bed*, which has locally been called the "*M vein*," is without doubt the most important coal bed in the *Meade Run basin*. Its reported thickness ranges from 3 to 5 feet, and it has been proven on its outcrop along Meade, Oyster, and Johnson runs, and their branches. On the Faust farm, in the south-eastern corner of warrant 4369, the bed was opened at an elevation of 1760 feet, at what is known as opening No 6. The reported section of the bed at this place is as follows (Fig. 74, page 230):

1. Gray shale,	3
2. *Coal*,	4
3. Fireclay,	2
Total,	9

Mr. Faust reports that the bottom bench of the *Upper Freeport bed* was opened 46 feet above the *Lower Freeport bed* on the Faust farm.

It is difficult to determine the absolute thickness of

*In the sections of the coal measures accompanying this report fire-clay beds are placed under the coal beds, wherever they have been found. Where the fire-clay has not been actually proven, no mention is made of it in the section. This fact, however, does not necessarily imply its absence, since fire-clay, with scarcely an exception, forms the floor of all the bituminous coal beds in Pennsylvania.

rocks between the different coal beds in the *Meade Run basin*, on account of the distances between the points of observation, and the difficulty of making a proper allowance for the local and general dips of the coal measures. The measurements given in the general section (Fig. 64) may be taken as an average for the entire basin.

In the vicinity of Meade Run school-house, warrants 4342 and 4343, the *Lower Freeport bed* was opened in a number of localities by the Pennsylvania Cannel Coal Co. over 20 years ago.* It is reported to have been found with a thickness running from 3 to 5 feet, the coal on analysis giving 62 per cent of fixed carbon, and comparatively little ash, and making a strong fuel.

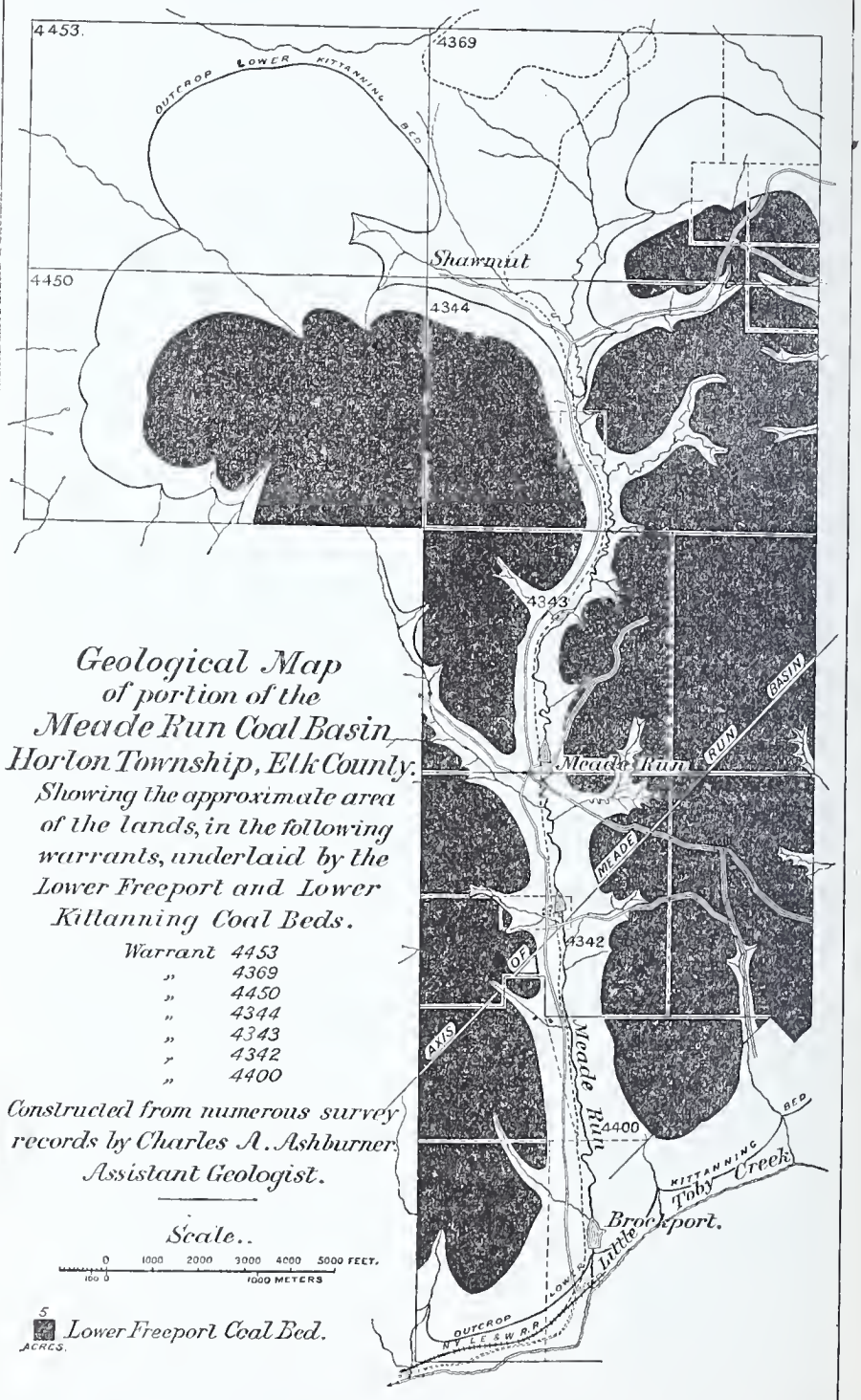
On the west side of Meade run, about 2000 feet north of Meade Run school-house, the bed was opened at an elevation of 1710 feet, and on the south side of Gravelick run, and south-east of the same school-house, at an elevation of 1650 feet. The thickness of the bed at the latter point is reported to have been 4 feet 7 inches. South of this latter opening, a tunnel was driven through the hill a distance of 896 feet, having a course S. 68¼° E. The elevation of the western end of the tunnel is 1650 feet, and the bed is reported to be nearly horizontal in the tunnel. The axis of the *Meade Run basin*, as nearly as can be determined, passes through this tunnel and has a direction of about N. 40° E.

On Rolle run (west of Meade run) on warrant 4400 the *Lower Freeport coal bed* has been opened at an elevation of 1670 feet, the bed being 4 feet 2 inches thick.

The fact that this coal bed contains without doubt the best coal in the *Meade Run basin* and is most advantageously situated of any coal bed, for economical mining, seems never to have been appreciated, or the badly planned mining operations of the Shawmut Coal Co. would never have been made. It is not, even now, generally believed that the *Lower Freeport bed* of the Reynoldsville and the Punxsu-

*The relative position of the coal beds in the vicinity of Meade Run S. H. is shown in Fig. 71, page 230. constructed from Eiche's surveys. Considerable cover exists over the *Upper Freeport bed*, not given in the section.

HORTON TOWNSHIP.



Geological Map
of portion of the
Meade Run Coal Basin
Horton Township, Elk County.

Showing the approximate area of the lands, in the following warrants, underlaid by the Lower Freeport and Lower Kittanning Coal Beds.

Warrant	4453
"	4369
"	4450
"	4344
"	4343
"	4342
"	4400

Constructed from numerous survey records by Charles A. Ashburner Assistant Geologist.

Scale..

0 1000 2000 3000 4000 5000 FEET.
100 0 1000 METERS

5 ACRES. *Lower Freeport Coal Bed.*

O.B.H.

tawney regions in Jefferson county, and the "*Moshannon bed*" in Clearfield county, are represented by a coal bed in Elk county. There is no doubt but that the famous coal bed of these localities is represented in the *Meade Run basin*, and, although it has never been mined, the meager facts which have been reported as to its thickness and composition certainly warrant thorough exploration. The area* which is underlaid by this bed in the *Meade Run basin* is shown on the accompanying map, page 234.

The *Lower Freeport limestone* occurs from 50 to 55 feet below the *Lower Freeport coal bed*, the interval between being composed principally of shale, slate, and fire clay, and containing two coal beds, the upper one being known as the "*Cannel or L vein*," and the lower one as the "*K vein*."

The *Lower Freeport limestone bed* is easily distinguished from that of the *Upper Freeport*, the *Johnstown cement* or the *Ferriferous bed*. It is generally composed of a pearl gray, rather fine-grained and brittle stone with a conchoidal fracture. Specimens collected from three localities gave the following analysis (A. S. McCreath):

	McAllister farm.	Fox farm.	Chamberlain farm.
Carbonate of lime, ...	69.357	57.321	81.875
Carbonate of magnesia, ...	9.308	8.854	7.189
Oxide of iron and alumina, . .	4.835	7.940	2.750
Phosphorus, ...	077	038	066
Insoluble residue, ...	13.680	21.250	6.540

The *Cannel bed* has a very irregular thickness, but is sometimes found as much as 2 feet thick; at other times thinning down to a knife edge. It was opened at Shawmut opening No. 1 at an elevation of 1795 feet, and at Shawmut opening No. 2 at an elevation of 1775 feet, both openings being near the head of North run, in warrant, 4344. At opening No. 3 along the same run the bed was opened at an elevation of 1750 feet, and was reported to be 2 feet 6 inches thick, a drift being driven in the bed for a distance

* From recent surveys there appears to be over 3 000 acres of the Shawmut Coal Company's lands underlaid by the *Lower Freeport coal bed* and over 3,600 acres under the blackened area indicated on the map of portion of the *Meade Run basin*, on page 234.

of 60 or 70 yards. The interval between the "*L*" and "*K*" beds varies from 14 to 20 feet.

The "*K vein*" ranges from 2 feet 6 inches to 4 feet thick, and is composed of a bright coal, which is locally mined and valued as a fuel. This bed invariably occurs from 5 to 10 feet above the *Lower Freeport limestone*. It and the limestone are the most easily recognized strata in the coal measures of Horton township.

On Faust run the "*K vein*" was opened at an elevation of 1720 feet and reported to be 2 feet 6 inches thick, the *Lower Freeport limestone* at this point being found about 3 feet below the coal bed. This coal bed has been opened about 2000 feet north of the Meade Run school-house, at an elevation of 1665 feet, and 2000 feet southeast of the school-house, at an elevation of 1615 feet. On Rolle run, in the northern part of warrant 4400 and near the center of the *Meade Run basin*, the bed was opened at an elevation of 1625 feet, the thickness of the bed being reported to be about 3 feet.

The great thickness of the strata between the *Lower Freeport coal bed* and the *Lower Freeport limestone* in the *Meade Run basin* is exceptional, and the occurrence of two coal beds, one of which ("*K vein*") can certainly be considered of workable thickness, has no parallel, as far as I am aware, either in Jefferson or Clearfield county. The local thickening of these measures and the occurrence of two coal beds in them is, however, not an anomaly in our Pennsylvania geology. Many instances of a similar occurrence might be cited in different parts of the section of the Lower Coal Measures, not only in the bituminous, but in the anthracite coal fields.

That the names assigned to the different coal beds of the Horton township section are correct, there seems to be but little doubt, since my conclusions have been based not only upon examinations in Elk county, but upon a comparison with those in adjoining counties.

The *Kittanning group*, extending from the *Ferriferous limestone* up to the FREEPORT SANDSTONE, has an average thickness of 124 feet, and includes three coal beds, the

Upper, *Middle* and *Lower Kittanning beds*, each one having an average thickness of 3 feet.

The *Johnstown Cement bed*, which is found between the *Upper* and *Middle beds*, is an exceedingly hard, siliceous limestone. Sometimes the bed becomes so sandy that it is hard to distinguish it from a sandstone.

On J. McAllister's farm this limestone or cement bed occurs 20 feet above the *Middle Kittanning coal bed*, has a thickness of 4 feet (see section 65, page 226) and possesses the almost universal and easily recognized characteristics of the *Johnstown Cement bed*, being sandy, rather coarse-grained, very hard and tough, and having a light, bluish-gray color. Specimens from the bed gave an analysis (A. S. McCreath):

Carbonate of lime,	80.257
Carbonate of magnesia,	1.619
Oxide of iron and alumina,	3.610
Phosphorus,	086
Insoluble residue,	12.290

The *Kittanning beds* have been opened on their outcrop in a number of localities. The *Upper bed* was found not far from No. 2, at an elevation of 1715 feet. Its thickness is 2 feet. The same bed ("*I vein*") was opened 85 feet above mine No. 8; the following section was measured (Fig. 70, page 230.):

1. Slate,	3'+
2. *Coal, bony*,	4'
3. Slate,	2+
Total,	9'

A car load of coal is said to have been shipped from this opening and tested, both for gas and steam purposes; with what result, I am not aware.

The *Kittanning Middle bed* has a variable character; on North run it was found to be but 1 foot thick, and at an elevation of 1690 feet.

The *Kittanning Lower coal* has been thoroughly developed at mine No. 8, at the end of the Shawmut and Ridgway railroad. The elevation of the bed here is 1605 feet. The coal varies from 3 feet to 3 feet 6 inches thick; the

roof is generally black slate, but sometimes sandstone. I am told that the thicker coal, as a rule, is found under a sandstone roof.

Some of the local authorities consider this bed to be the same as that which was worked by the Shawmut Company at their No. 7 mine.

From all the surface facts which I could gather, I believe that No. 8 coal occurs above the *Ferriferous limestone*, and No. 7 coal below the same limestone. I was unable to examine the maps of these mines, which, of course, would furnish the best evidence possible on the subject. If the identification which is proposed is the correct one, the bed at mine No. 8 is the same bed as that which is being mined by the North-western Mining and Exchange Company, at Centerville, and by the St. Mary's Coal Company, on the Philadelphia and Erie railroad.

The *Kittanning Lower coal* passes under water-level at No. 8 mine, and does not outcrop again along Meade run, except near its mouth.

The *Clarion coal bed* has been mined at mine No. 7, the mouth of which is some 800 feet, more or less, south-east of the company store at the village of Shawmut. The elevation of the drift mouth is 1685 feet. Along the outcrop the bed dips about 30 feet in 425 feet south 50° east. The coal is 2 feet 6 inches thick, with a slate roof and fire-clay floor. This mine was opened in 1867, and worked for about two years. Near the mine a drill hole was put down a distance of 200 feet. I could not procure a record of the strata passed through, but I am told that immediately below the coal bed was found a hard massive sandstone.

What appears to be the same coal bed (*Clarion*) was worked at mine No. 16, located about half a mile north-east of the company store. Its elevation is 1725 feet. The bed was 2 feet 10 inches thick, and contained a small streak of sulphur; it had a black slate roof and fire-clay floor. The roof at the mine was not very solid, and the coal was consequently rusty. The mine was opened in 1864, work was commenced in 1865, and coal shipped for two years. When No. 7 was opened, No. 16 was abandoned.

Mine No. 15 is located about half a mile north-east of Shawmut, and near mine No. 16. The bed was 2 feet 6 inches thick and the elevation of the mine mouth 1845 feet. The bed has a black slate roof and fire-clay floor. The mine was opened in 1864 and worked for about one year. It was abandoned on account of the difficulty of shipping the coal. I have not sufficient facts to establish the identity of this coal bed, but it is probably one of the *Kittanning beds.*

A coal bed was opened, at an elevation of about 1755 feet, two-thirds of a mile west of mine No. 7, at what is known as the "*Water vein opening.*" The bed measured 3 feet on the outcrop. As the degree of dip is not known at this point, and as the face of the coal bed was not seen, I failed to establish its identity.

It must be remembered that the elevations above tide in the *Meade Run basin*, and generally throughout the county, were determined by an aneroid barometer, and therefore cannot be assumed to be absolutely correct. The profiles have, however, been subjected to so many tests that the elevations are sufficiently accurate for geological purposes.

Before any further work is done in the township, with a view of mining, the elevations of coal openings and coal outcrops should be carefully determined, with an engineer's level, and the dips of the coal measures computed. The best and most economical location for a mine or mines can be thus ascertained.

The foregoing facts indicate the general extent and value of the coal beds of the *Meade Run basin.* Numerous analyses have been made, of the coals from the several beds, which attest their value for steam and gas coals. No chemical examinations have been made of any of the Horton township coals by the State Survey, as it was impossible to obtain specimens suitable for analysis.

On the hill east of Brockport, and alongside the road, the *Ferriferous limestone* has been quarried, at an elevation of between 140 and 150 feet above the Brockport store. The face of the limestone has been exposed 7 feet high and 50 feet long. The lower and upper parts of the bed are composed of shaly, very ferruginous, and highly fossiliferous

layers, and are of a darker color than the more massive central part, which measures from 4 feet to 4 feet 6 inches thick.

The outcrop of a coal bed was found above the limestone, but the vertical distance between it and the limestone was not determined. Forty feet below the limestone the *Clermont or Clarion coal bed* has been opened, and its thickness reported to be 3 feet. Near the Brockport store, one of the *Alton coal beds* has been opened.

The Toby creek, at the Brockport cross-roads, has eroded its bed out of the KINZUA CREEK SANDSTONE, and the blocks of coarse-grained sandstone, which are found in the vicinity, come either from this rock or from the JOHNSON RUN SANDSTONE.

The dip toward the west, from the limestone quarry to the hill capped by the MAHONING SANDSTONE, in the vicinity of Theodore Fox's house, is very rapid, being at about an average rate of 135 feet per mile.

In the bed of the Toby creek in Snyder township, Jefferson county, and but a short distance from the Jefferson-Elk line, the *Ferriferous limestone* outcrops in the bed of the creek. The limestone is 10 feet thick, 8 feet being exposed above water level (Sept. 13, 1883), and 2 feet below. The exposure consists of seams of limestone from 1 to 3 inches thick, which are heavily charged with iron. The structure of most of the limestone, where exposed, is concretionary, and the concretions contain the most iron. Small seams of iron pyrites and calcite are found running through portions of the limestone beds. The limestone seams alternate with blue and gray slate, from a few inches to 1 foot in thickness.

Immediately under the lower limestone seam were found pieces of outcropping coal (*Ferriferous coal bed*). The thickness of the coal bed, however, was not ascertained.

The high percentage of iron which the *Ferriferous limestone* is found to contain, not only at this locality, but at others in the district, has led many to suppose that it was a workable bed of iron ore. While selected concretions will probably run high enough in iron to make it possible to use them as an iron ore, in the furnaces, no hope should

ever be entertained that the *Ferriferous limestone* will be found in this vicinity containing a percentage of iron sufficiently high to make it profitable to mine as an iron ore. This limestone bed is the same as is quarried in the hill east of Brockport. There is a considerable dip in the bed toward the south-west, in order to bring it down to the level of the creek in Snyder township.

A short distance south-west of the limestone in the stream, a coal bed has been worked at the *Stevens mine*, at an elevation of about 55 feet above the top of the limestone. This coal bed is probably the representative of the *Lower Kittanning*.

The structure of the *Toby basin* between Brockport and Brockwayville is confusing, and has led many astray. According to Mr. W. G. Platt (see section No. 9, Plate No. VII in the Atlas), in the higher hills in the vicinity of Brockwayville there is about 100 feet of cover over the *Freeport Upper coal bed*. At Brockport the bottom of the valley is cut down to the level of the KINZUA CREEK SANDSTONE. This sandstone, in this vicinity, is at least 370 feet below the *Freeport Upper coal bed*, so that the dip of the strata toward the south-west, along the Toby creek, toward Brockwayville, is considerable.

Chapter No. XII.

Benezette Township.

Benezette lies east of Jay, south of Shippen, and west of Gibson in Cameron, and north of Girard and Goshen in Clearfield.

The township lies entirely within the Susquehanna water-basin, and is drained by the Bennetts branch of the Susquehanna River and its branches, the more prominent of which, of those flowing into it on its left bank, are Hicks, Dents, and Trout runs, and, of those on its right bank, Mix, Johnson, and Meadic runs. The south-eastern corner of the township is drained by Mosquito creek, which flows into the west branch of the Susquehanna in Karthaus township, Clearfield county.

The topography of the north-western half of the township, or that portion lying within the *Cameron or Caledonia* (*Third*) *coal basin*, is similar in all of its features to that of Jay township; in fact, there is no prominent feature which will distinguish its surface from that of Jay. This close relationship results, naturally, from the fact that its surface is underlaid by the same strata, and its geological structure is a continuation to the north-east of that found in Jay.

The topography of the south-eastern half of the township is, in a general way, quite different from that north-west of Bennetts branch. The valleys are not as deeply cut, the slopes of the hills are not generally as steep, and the tops of the hills are broader and flatter. This is due to the fact that the lower part of the COAL MEASURES, No. XIII, and the members of the POTTSVILLE CONGLOMERATE, No. XII, are lifted by the *Driftwood anticlinal* to a much greater height than that at which the same strata are found in the *Cameron basin*, in the north-western

portion of the township. The result is that the surface in the south-eastern portion is not underlaid by these harder strata. The topography here is not unlike that referred to in southern Spring Creek township.

The highest point measured in the township is at the headwaters of Mix run, in the southern part, near the line between Clearfield and Elk counties, at an elevation of 2130± feet. The lowest point is where the Bennetts branch crosses the county line, near the village of Dents Run, the elevation being about 1100 feet.*

The north-western part of the township lies in the *Cameron or Third Bituminous coal basin*, the axis of which is nearly due north-east and south-west, crossing Trout run about a mile and a half north-west of the village of Benezette.

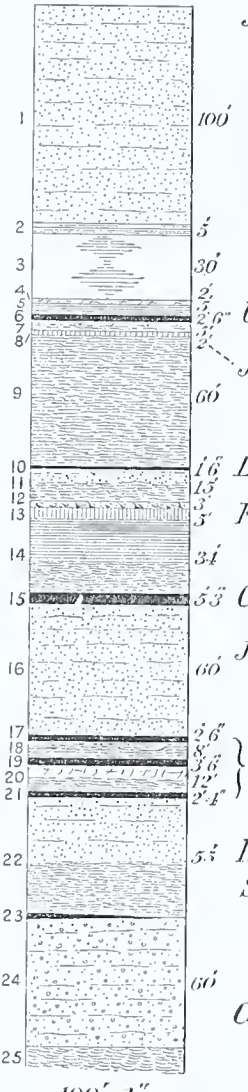
The *Driftwood or Second anticlinal axis* cuts across the south-eastern corner of the township. The location of this axis, along the line between Elk and Clearfield, is not very clearly defined. The elevations of the summits measured in this vicinity, which are capped by the members of the POTTSVILLE CONGLOMERATE, would seem to indicate that this anticlinal axis bends to the west, and enters Clearfield county nearer the south-western corner than the south-eastern corner of the township. The summits in the south-eastern half of the township are very nearly of equal height, and the strata have been elevated so high by the *Driftwood anticlinal* that the PRODUCTIVE COAL MEASURES have been almost entirely eroded, leaving nothing but the OLEAN CONGLOMERATE, and possibly the KINZUA CREEK SANDSTONE, immediately underlying the surface.

No coal openings or outcrops, with the exception of those seen on the headwaters of Meadic run, referred to later, were found in this portion of the township, and it is highly improbable that areas of any considerable extent will be found to be underlaid by any coal beds here. They certainly are not underlaid by any coal beds of workable dimensions or purity.

* Elevation of Dent's Run station, B. Br. RR., is 925.8 feet above ocean level.

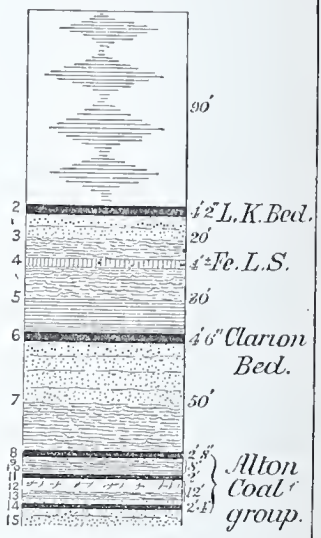
Sections in Caledonia Basin, Benezette Township.

Fig. 75. p. 245.
Benezette and Caledonia.



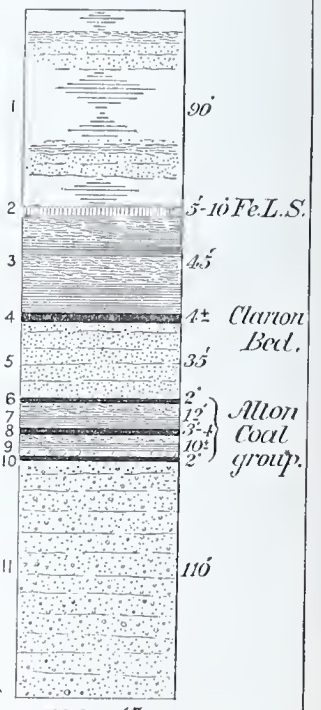
100′ = 1″

Fig. 76. p. 252.
Slide Run.



100′ = 1″

Fig. 77. p. 253.
North-east of Benezette.



100 = 1″

Fig. 78. p. 255.
Clermont Bed Winslow's opening.

10′ = 1″

The north-western half of the township, which lies in the *Cameron basin*, contains all the productive coal beds which have been found in the township. These features are clearly shown on the geological map of Cameron county, and of Benezette township, Elk county, (Atlas RR, Plate III.) Explorations, which have been made since this map was constructed in 1879, make it necessary to modify somewhat the representation of the geology of Benezette township.

The known strata in this township extend from the MAHONING SANDSTONE down to the top of the CHEMUNG, in the Benezette dry hole. The lower part of the MAHONING is found on the highest summits west and south-west of Benezette, and the lower part of the CATSKILL, the lowest outcropping formation, near the mouth of Hicks run, in the vicinity of the village of Dents Run. The total thickness of strata, to the bottom of the Benezette hole, is 1639 feet.

The Benezette dry hole, although drilled to a depth of 721 feet, only penetrated 200 feet below the lowest outcropping stratum near Dents run; that is, the rock which was encountered in the bottom of the Benezette hole, underlies Dents run at a depth of probably not over 200 feet. These strata are of CARBONIFEROUS and DEVONIAN AGE, and may be sub-grouped as follows:

COAL MEASURES, INCLUDING THE POTTSVILLE CONGLOMERATE (No. XII),	475′
MAUCH CHUNK RED SHALE (No. XI.)	50′
POCONO SANDSTONE (No. X),	610′
RED CATSKILL SANDSTONE (No. IX),	490′±
CHEMUNG SHALE (No. VIII),	14′±
Total,	1639′

The coal measures between Benezette and Caledonia may be represented by the following compiled section, which is illustrative of the strata in Jay as well as Benezette (Fig. 75, page 244):

1. Sandstone and shale,	100′
2. Black slate,	5′
3. Concealed,	30′
4. Fire-clay,	2′
5. Black slate,	5′
6. *Kittanning Upper coal bed*,	2′ 6″

7.	Fire-clay and shale,	5′
8.	*Limestone, Johnstown cement bed,*	2′
9.	Ferruginous shales,	60′
10.	*Kittanning Lower coal bed,*	1′ 6″
11.	Sandstone and shale,	15′
12.	Ocher clay and iron ore,	3′
13.	*Ferriferous limestone,*	5′
14.	Slate and shale,	34′
15.	*Clarion coal bed,*	5′ 3″
16.	Sandstone and shale, JOHNSON RUN SANDSTONE,	60′
17.	*Alton Upper coal bed,*	2′ 6″
18.	Shale,	8′
19.	*Alton Middle coal bed,*	3′ 6″
20.	Fire-clay and shale,	12′
21.	*Alton Lower coal bed,*	2′ 4″
22.	Sandstone and shale, KINZUA CREEK SANDSTONE,	55′
23.	*Marshburg Upper coal bed,*	—
24.	Sandstone and conglomerate, OLEAN CONGLOMERATE,	60′
25.	MAUCH CHUNK RED SHALE, No. XI,	
	Total,	478′ 7″

The highest stratum in this section, which it was possible to identify, was the *Kittanning Upper coal bed.* The strata composing the interval of 142 feet above it were only exposed at intervals, and the section in this part is very unsatisfactory. The top strata probably represent the MAHONING SANDSTONE, and if so, then the *Freeport coals* and *limestones* should find some representatives below it, and above the *Kittanning Upper bed.* It is possible that the *Freeport coal beds* have deteriorated so much in thickness that they will never be found here of workable dimensions; in fact, their floor and roof rocks may have come together and entirely cut them out.

The most important coal beds in this series are the *Clermont and Alton coals*, which have been opened in a number of localities, referred to below.

The *Clermont bed*, which is 5 feet 3 inches thick, with its fire-clay overlies the JOHNSON RUN SANDSTONE, which is the top member of the POTTSVILLE CONGLOMERATE group. All of these sandstones are boldly defined in Benezette township, and the JOHNSON RUN ROCK has a greater thickness in Jay and Benezette than anywhere else in the district, except in the *Johnson Run basin*, where it attains a thickness of 75 feet.

The bottom of the OLEAN CONGLOMERATE in the vicinity of Benezette is at an elevation of 1450 feet, or 445 feet above the top of the Benezette dry hole.

The interval of between 40 and 60 feet immediately under the OLEAN CONGLOMERATE is composed of red and gray shales and thin bedded sandstones. These represent the MAUCH CHUNK RED SHALE No. XI. The lithological character of these strata, wherever they were seen, was very much the same, but in some localities they were composed of red colored shales, while in others no red shales were observed.

The absence of any indications of red shale under the OLEAN CONGLOMERATE, in some localities, may be due to the fact that the red shales are more easily eroded than the alternating gray and green shales, and that they may be covered up by the debris coming from the weathering of the overlying strata. The gray and green shales, not being so easily affected by the weather, are found outcropping. I believe, however, that, in a great many localities throughout Cameron and Elk counties, the No. XI shales, where the edges of the strata are covered, possess practically the same constitution as where they outcrop, the only difference being in the coloring.

The interval of 395 feet, between the MAUCH CHUNK strata and the top of the Benezette well, is filled mostly by green and gray, thin-bedded, flaggy sandstones and shales. No continuous outcrop of these strata was found in the vicinity of Benezette. In the lower part of this interval of 395 feet occur three beds of limestone, the relative positions of each being shown in the following section:

1. *Upper limestone,*	7′
2. Gray and olive shale and slate,	5′
3. Gray and greenish-gray hard argillaceous sandstone,	60′
4. *Middle limestone,*	2′
5. Gray and greenish shales,	60′±
6. *Lower limestone,*	2′
Total,	136′±

The *Upper limestone* is fossiliferous; the fragments of the shells, however, are so imperfect that their species could

not be determined. It contains slate and shale bands, and iron and clay balls. There is a strong dip of the bed toward the west, at the rate of 3 or 4 feet to the 100 feet. I was informed by Mr. Simon P. Romig, who lived at Benezette in the fall of 1879, when the examination was made, that the limestone from the lower bed was easily burned, and produced a white and brown lime, which was found to be an excellent fertilizer. In 1874 Mr. Romig reported that he had burned 300 bushels of lime from this bed.

The strata underlying Benezette are represented in the section of the Benezette dry hole. This hole was originally a salt well, and was drilled to a depth of 600 feet about 20 years ago. The hole was 3 inches in diameter, and salt water was thrown up over the derrick, by gas, for half an hour at a time. The water came from a depth of 300 feet. It was afterwards drilled to a depth of 721 feet in search of oil, and was abandoned in February, 1878. The record is as follows:

Well mouth above ocean, in feet,			+1005′
1. Conductor,	7′ to	7′	= 998′
2. Red and gray rock,	10′ "	17′	= 988′
3. Gray shale,	40′ "	57′	= 948′
4. Red rock,	4′ "	61′	= 944′
5. Gray slate,	12′ "	73′	= 932′
6. Red rock,	18′ "	91′	= 914′
7. Blue slate,	8′ "	99′	= 906′
8. Blue sandy rock,	4′ "	103′	= 902′
9. Blue slate,	20′ "	123′	= 882′
10. Hard blue limestone,	7′ "	130′	= 875′
11. Light slate,	4′ "	134′	= 871′
12. Dark slate,	18′ "	152′	= 853′
13. Sandy slate,	26′ "	178′	= 827′
14. Slate,	22′ "	200′	= 805′
15. Red rock,	4′ "	204′	= 801′
16. Gray hard rock,	3′ "	207′	= 798′
17. *First sand*,	10′ "	217′	= 788′
18. White clay,	8′ "	225′	= 780′
19. Red rock mixed with green slate and gray rock,	400′ "	625′	= 380′
20. Gray sandstone,	8′ "	633′	= 372′
21. Red rock,	24′ "	657′	= 348′
22. Hard gray and blue rock,	42′ "	699′	= 306′
23. Red rock,	8′ "	707′	= 298′
24. Gray rock,	6′ "	713′	= 292′
25. *Second sand*, (not through,)	8′ "	721′	= 284′

The original well, to a depth of 600 feet, was drilled by water power. The water which was encountered in the well was not cased off. The well was subsequently "reamed out" to a diameter of eight inches, to a depth of 398 feet, where the water was cased off by a $5\frac{5}{8}$ inch casing, and below this the hole was continued with a diameter of $5\frac{1}{2}$ inches. The bed rock was struck at a depth of 7 feet below the surface, and a gas vein was encountered at a depth of 376 feet.

The top of the RED CATSKILL is probably defined by the bottom of the stratum which is indicated as "*First sand*" (No. 17). The drill was probably stopped in the CHEMUNG ROCKS. As to this, however, it is impossible to say, as we have not sufficient definite information, as to the character of the rocks below water level in this part of Elk county, and the adjoining territory of Cameron county, to establish the thickness of the CATSKILL ROCKS.

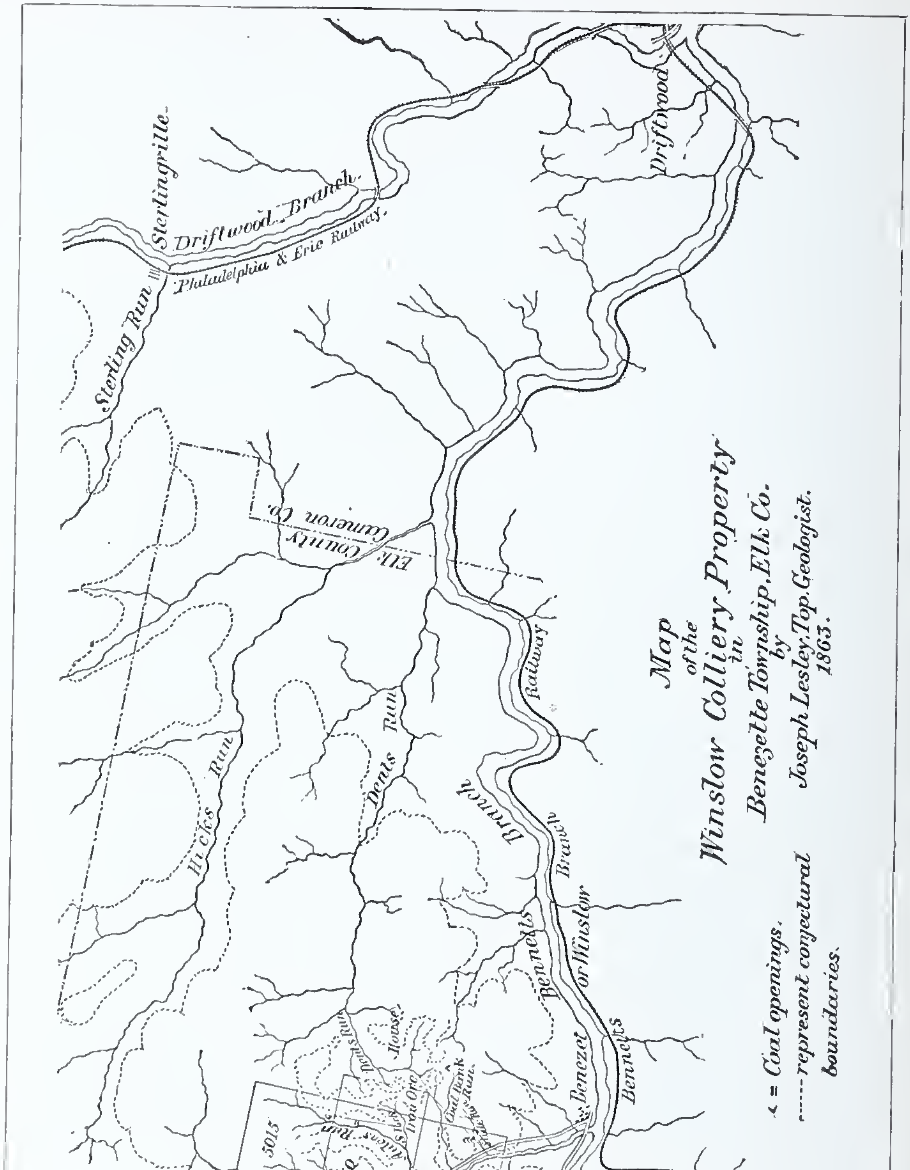
At Driftwood, which is 11 miles in an air-line about east 8° north of Benezette, there is 500 feet of CATSKILL rocks exposed above water level. In the Cameron well, which is about 13 miles north-east, the RED CATSKILL rocks were drilled through, and found to be 347 feet thick.

At Emporium, about 15 miles north 25° east, the CATSKILL ROCKS, which are exposed entirely above water level, are 350 feet thick.

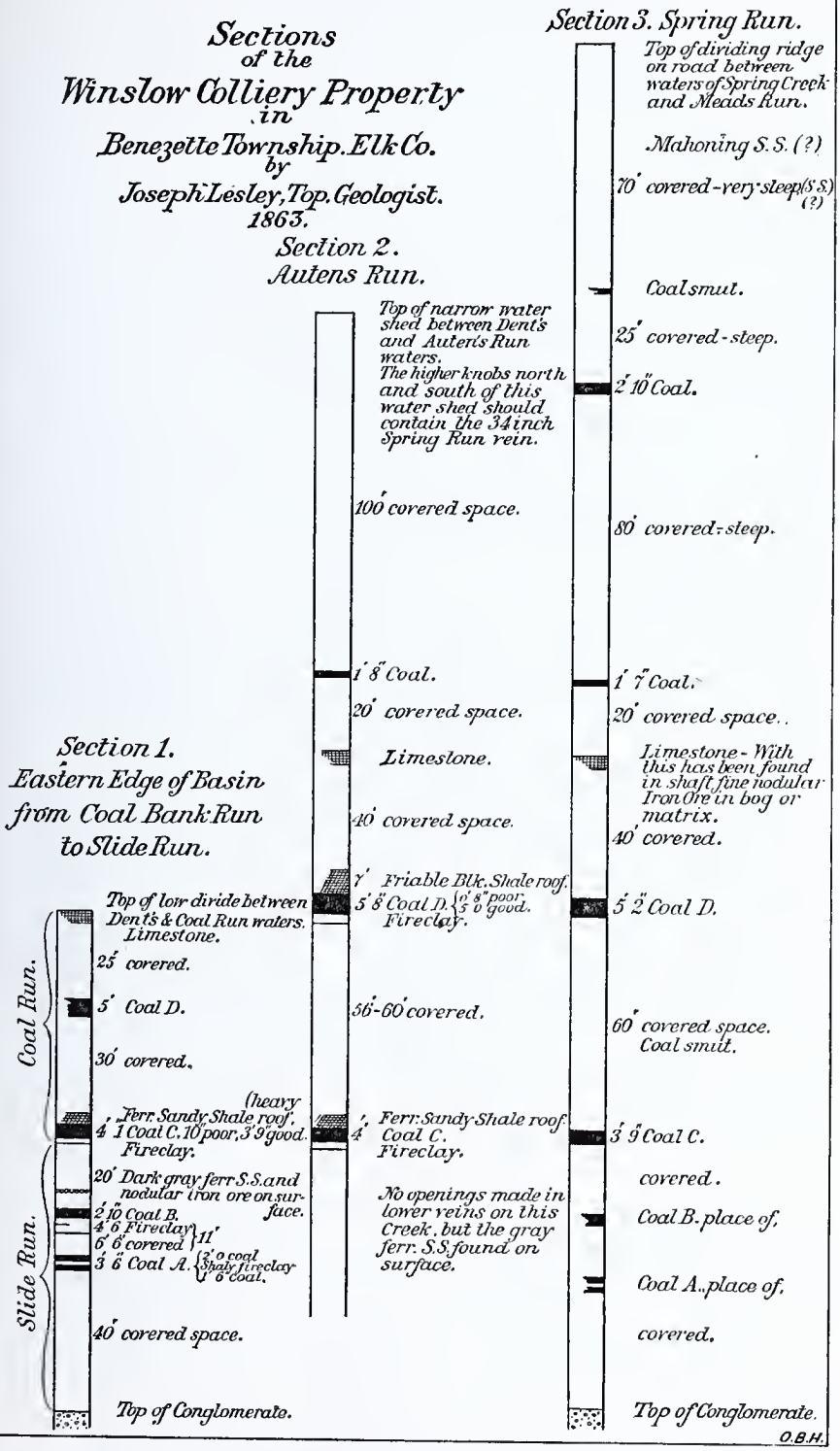
The determination of the thickness of the CATSKILL ROCKS, in the vicinity of Benezette, would be of practical importance, if there was any probability of finding a productive oil field in this locality. As it is improbable that oil will be found in this section of the State, as stated elsewhere, (Part I of this report,) it is a matter of no practical concern, as to what the actual thickness of this formation is, in the vicinity of Benezette.

The coal beds and limestones contained in the LOWER PRODUCTIVE COAL MEASURES in Benezette township are well exposed north of the Bennetts branch, between Benezette and Dents run.

A number of examinations have been made of the areas underlaid by these coal beds, and, although the general conclusions which have been stated in these reports, as to


Map
of the
Winslow Colliery Property
in
Benezette Township, Elk Co.
by
Joseph Lesley, Top. Geologist.
1863.
= Coal openings.
----- represent conjectural boundaries.
Sterlingville
Driftwood Branch
Philadelphia & Erie Railway
Sterling Run
Driftwood
Elk County
Cameron Co.
Hicks Run
Dents Run
Railway
Bennetts Branch
or Winslow Branch
Benezet
Bennetts
Trout Run
Spring Run
Lick Run
Wolf
Caledonia
Ore Bank
S.S.Knob
5015
5030
5023

Sections of the Winslow Colliery Property in Benezette Township. Elk Co. by Joseph Lesley, Top. Geologist. 1863.



the identity of the coal beds with those in other sections, I believe are wrong, yet they contain a great deal of valuable and correct information in regard to the coal beds. I refer more particularly to the reports of Prof. Rogers and Dr. Charles T. Jackson of the First Survey, and of Mr. Joseph Lesley.

Mr. Lesley made a reconnaissance survey in November, 1863, on what has long been known as the Winslow colliery property, along Trout run and Spring creek and their branches, in warrants 5015, 5020, and 5027. This report was published in the early part of 1864, and, although it contains the results of a very hurried and reconnaissance survey, it probably has more correct information than any report on the geology of this region that has come to my notice.

Mr. Lesley's map and sections have been reproduced from his report and are published on pages 250 and 251.

Mr. Lesley's estimates of the amount of coal contained on this property are very general, as they necessarily would have to be, from the character of his survey.

A more extensive survey, and opening of the coal beds, along their outcrops, I believe will have to be made, before any final estimates can be made of the amount of coal which this tract contains.

On the northern bank of Slide run, in the eastern part of warrant 5027, the three coal beds of the *Alton group* have been opened, and at a short distance from these openings, near Coal Bank creek, the *Clermont* and *Lower Kittanning beds* have been opened. The section of the measures here is as follows (Fig. 76, page 244):

1.	Interval, measures concealed,	90′
2.	*Lower Kittanning coal bed*,	4′ 2″
3.	Sandstone and shale,	20
4.	*Ferriferous limestone*,	4′±
5.	Shale and slate,	30′
6.	*Clarion coal bed*,	4′ 6″
7.	Sandstone and shale,	50′
8.	*Alton Upper coal bed*,	2′ 8″
9.	Shale,	6′
10.	Black slate,	2′
11.	*Alton Middle coal bed*,	2′

12. Fire-clay and shale,	10′
13. Coarse gray ferruginous sandstone,	2′
14. *Alton Lower coal bed*,	2′ 4′′
15. KINZUA CREEK SANDSTONE,	—
Total,	229 8′′

The *Alton Middle coal bed* could not be well measured, when I visited it, in September, 1879. The thickness of 2 feet, assigned to it above, was that reported by Mr. Simon P. Romig, who had opened it on the outcrop. I was informed by Mr. Petriken that this same coal bed, at other openings in the vicinity, showed a thickness of between 3 feet 6 inches and 4 feet. This bed is sometimes locally known as the "*Split bed.*" Mr. Lesley, in speaking of this bed, says that "it measures 2 feet 10 inches in thickness, with slate roofing and fire-clay floor; the coal is of a good quality, shows a columnar structure, is jet black."

The *Alton Upper bed* was being mined by Mr. Romig, when the opening was visited. The face of the drift was 150 feet from its mouth, and the bed varied in thickness from 2 feet 8 inches to 2 feet 10 inches. An opening has been made on this same bed at the head of Autens run, and Mr. Lesley reports for it a thickness of 4 feet, and on Spring run, a thickness of 3 feet 9 inches. The average thickness of the bed is probably not far from 3 feet. This bed has been taken to be the representative of the coal which has been mined by the Cameron Coal Company, whereas the *Cameron bed* is the *Lower Kittanning*, and is represented by the upper bed in the Slide run section.

The elevation of the *Lower Kittanning bed*, where examined, was 1475 feet, of the *Clarion bed*, 1405 feet, and of the *Alton Lower bed*, 1335 feet.

A number of coal openings have been made along the road running north-east from Benezette, on the divide between the headwaters of Dents run and several small streams flowing into the Bennetts branch. The general compiled section of the measures, as observed here, is as follows (Fig. 77, page 244):

1. Shale and sandstone, exposed at intervals,	90′
2. *Ferriferous limestone*,	5′ to 10′
3. Shale and slate,	45′

4. *Clarion coal bed*,	4′±
5. JOHNSON RUN SANDSTONE,	35′
6. *Alton Upper coal bed*,	2′
7. Shale, slate, and fire-clay,	12′
8. *Alton Middle coal bed*,	3′ to 4′
9. Shale and slate,	10′±
10. *Alton Lower coal bed*,	2′
11. KINZUA CREEK SANDSTONE and OLEAN CONGLOMERATE,	110′
Total,	318′ +

The *Ferriferous limestone* is exposed at a number of localities along the summit, and has been quarried and burnt for lime, which has been used extensively as a cement and a fertilizer. Its thickness varies from 5 to 10 feet. The bottom of the limestone on George W. Winslow's farm was found at an elevation of 1610 feet. The stone is very hard, massive, and brittle, in places very ferruginous, and contains a number of imperfect fragments of fossil shells. At this point the face of the bed measured 7 feet thick.

About 6 feet under the bottom of the limestone was found a small streak of coal from 2 to 3 feet thick. This coal is the representative of the bed found under the limestone in Fox township, and at *Kane's quarry* in Jones township. Although this coal bed cannot be always found underneath the limestone, yet, when it exists, it is one of the distinguishing features of this stratum.

At *Winslow's lime quarry*, alongside of the kiln, the bed will probably be found at least 10 feet thick, when quarried further into the hill. In the center of the bed there is very frequently found 1 foot of very poor argillaceous limestone. *Winslow's limestone* is sometimes locally named the *Mount Pleasant bed.*

When *Winslow's quarry* was visited in 1879, it was producing from 30 to 45 bushels a day, a royalty of one cent a bushel being paid for the privilege. The run of the kiln at that time sold for 10 cents per bushel, being used as a fertilizer. When sold for plaster, it was necessary to pick the lime, and the price obtained for this grade was 14 cents per bushel. The experience of the kiln burner has been that 1 bushel of coal is required for every 6 bushels of lime obtained.

Some 40 feet below the bottom of the limestone, a coal crop was found, which is the representative of the *Clarion bed.*

Above the limestone occurs a lean iron ore, which it would never be profitable to work for the manufacture of iron, as the ore is not sufficiently rich in iron, and is not in sufficient quantity, to make such work profitable.

I was informed that a limestone bed had been found immediately below Mr. H. H. Wilson's house, but I did not see it.

It would appear that the hills along this summit, in places, are sufficiently high to contain a small area of the *Lower Kittanning bed.* Search was made for the outcrop of this coal, but it was not found, except in one locality.

East of Mr. George Winslow's house, an outcrop of the *Clermont coal bed* was located, the bottom of the bed being placed at an elevation of 1540 feet. Over the coal were found several outcrops of a gray ferruginous sandy shale, which is probably the character of the strata here between the coal bed and the limestone. An opening had been made on a coal bed at this point, and some coal had been mined out. It had fallen shut at the time that it was visited, but the following section was reported by Mr. Winslow (Fig. 78, page 244):

1. *Coal,*	1′	8″
2. Black slate,		10″
3. *Coal,*	2′	
4. Black slate,		2″
5. *Coal,*		6″
Total,	5′	2″

This section does not resemble the sections of the *Clermont bed* which I measured in the coal openings near Winslow's. It is thought that this bed outcrops in the hill immediately above Mr. Winslow's house.

Mr. Winslow struck a bed 2 feet thick in digging his cellar. This is probably the representative of the *Alton Upper bed.*

A bed, which I took to be the representative of the *Alton Middle coal,* has been opened a short distance from Mr.

Winslow's house, at an elevation of 1475 feet. A drift has been worked in the bed, 150 feet under the hill, and the bed measures 3 feet 10 inches thick, and has a dip of 3 feet to 100 feet, toward the mouth of the drift. The coal is easily mined, has a cubical and sometimes a columnar fracture, is bright, and the bed contains layers of cannelly coal and slate with sulphur. Some of the surfaces of the coal are highly iridescent.

What was supposed to be this same bed was opened at *Wilson's Drift*, at an elevation of 1500 feet, about a quarter of a mile a little south of east from *Winslow's coal bank*. The coal at Wilson's bank is 3 feet 10 inches thick, is hard, and has to be blasted in mining. The coal is rich black, has a columnar structure, and contains very little sulphur or slate. One piece of coal taken out of this drift, which I measured, was 1 foot 8 inches long by about 5 inches square.

A coal bed outcrops on the hill back of Mr. Wilson's house, and about 30 feet below the limestone at Winslow's quarry. This is probably the representative of the *Clarion coal bed.*

Mr. Winslow opened a lower bed, probably one of the *Alton group coals* on Dents run, half a mile north-east of his house. The outcrop of the bed was only dug into, and its thickness could not be determined. A short distance from this point, however, the same bed was opened by other parties, and measured 2 feet 8 inches thick.

The *Clarion bed* has been mined at the *Brown drift.* This drift is 250 feet in under the hill, and has a course of 10° to 15° east of north. The dip of the bed is toward the mouth of the mine. The thickness of the coal is about 4 feet. This drift was first opened about 30 years ago. The elevation of the bottom of the bed at the mouth is 1565 feet. The elevation of the top of the hill, immediately above the coal opening, is 1615 feet.

On *Israel Murray's farm* the same bed has been opened, and measured 4 feet 4 inches thick, without any separating slate or bony coal. The elevation of this opening is 1555 feet.

The same bed was opened, about 20 years ago, back of the

old barn on the Murray farm, at an elevation of 1575 feet. The thickness of the bed at this point was 4 feet. The coal which has been taken out of this latter opening was reported to furnish a good stove and grate fuel, but was not good for blacksmiths' use.

About 35 feet below this bed a coal has been opened in the bottom of the ravine near the school-house, in the southeastern corner of warrant 5021, which measured 2 feet thick on the outcrop. The bed is overlaid by black and gray slate, and is the *Alton Upper coal.*

On *George Morgan's farm* aside of the road, along the creek, descending from the school-house to the railroad, a bed of coal has been opened, at an elevation of 1485 feet, which is of a cannelly structure and is from 1 foot 9 inches to 2 feet thick. The bed is overlaid by from 3 to 4 feet of black slate, with a hard massive sandstone immediately above it. The coal is probably the representative of the *Marshburg Upper bed*, which lies between the OLEAN CONGLOMERATE and the KINZUA CREEK SANDSTONE.

On *John Overturf's farm* the *Clarion bed* has been opened at an elevation of 1615 feet, and measures 4 feet 2 inches thick. The coal taken from this opening is an excellent fuel, as is most of the coal mined from the *Clarion bed* in this vicinity.

On *James Cockburn's farm*, about half a mile northwest of *Overturf's coal bank*, a bed has been opened, at an elevation of 1490 feet, which measured from 1 foot 8 inches to 2 feet thick. The bed is overlaid by fire-clay, and is taken to represent the *Alton Lower bed.*

The *Clarion bed* has been mined on *Benjamin Johnson's farm*, at an elevation of 1650 feet. The bed is from 2 feet 8 inches to 3 feet thick, and is found in one continuous bench. The coal has a cubical fracture, and is rusty when mined. This latter feature is probably due to the roof rocks, which form a cover to the bed, measuring only 20 feet thick. From the greater elevation at which this bed was found, from its thickness being less than that of the *Clermont bed* at the *Overturf* and *Murray coal banks*, and from the rusty appearance of the coal, it was thought by Mr. Romig to occur

above the *Ferriferous limestone.* In this event it would be the representative of the *Lower Kittanning bed.* I think there is little doubt, however, that this bed is the *Clarion.*

The distance between the Johnson and Winslow farms is about 2 miles due west, and in this distance there is a dip in the *Clarion bed* of about 110 feet.

The best coal, in this vicinity, is undoubtedly to be found in the *Clarion bed*, and the different characteristics of this bed, where opened, I think, point to the conclusion, that the most profitable mining to be carried on in the vicinity of Benezette will have to depend upon the coal obtained from this bed.

Although the *Alton beds*, where they have been opened here, have been found of sufficient thickness to be economically mined, and in places, contain coal of sufficient purity to produce a good fuel, yet the character of these beds, as has been referred to elsewhere, is such, that little dependence, either as to thickness or the character of the coal which they will be found to produce, can be placed upon them, for extensive mining operations.

Although my observations and more extended survey of this district modify considerably Mr. Joseph Lesley's conclusions, both as to the area underlaid by the coal beds and the thickness of the intervals between the beds, yet our general results agree so closely, that those of each tend to confirm the others. For this reason it has been thought advisable to republish Mr. Lesley's map and sections,* although, as his report states, they are but the results of a reconnaissance. The relative positions of the coal beds, as established in Mr. Lesley's sections, are the same as those in my own, but the intervals between them vary as to thickness.

Iron Ore.

About a mile and three quarters from the mouth, on the eastern side, of Horton run, which empties into the Trout run about a mile and a half above its mouth at Benezette, near the junction of warrants Nos. 5015, 5014, 5020, 5021, considerable exploration has been done, in searching for

* See pages 250 and 251.

coal and iron. I believe that all searches for a profitable iron ore bed will prove fruitless in this vicinity.

What was supposed to be an *iron ore bed* was found at an elevation of 1535 feet. Upon examination, the supposed iron ore bed was found to be the outcrop of the *Ferriferous limestone*, which in this locality was heavily charged with iron, not containing sufficient iron, however, to make it possible for it to be used in manufacturing.

An analysis of the most ferruginous pieces of the limestone, made by Messrs. Booth, Garrett and Blair, was furnished me. Although this analysis shows iron in workable proportions, yet it is not any indication of the amount of iron which would be the run of the mine, if the bed should be worked. The limestone has all the characteristics of the *Ferriferous bed*, as it is found in many localities. Although highly ferruginous at this point, it does not contain as much iron as the limestone outcrop in the bed of Toby creek, at Balltown,* immediately south of the Elk county line.

This Horton run limestone outcrop is very nearly in the center of the *Caledonia basin*, and about a mile north-west of Winslow's limestone quarry. The elevation of the limestone in the two localities shows a dip toward the north-west of 75 feet, which is about what might be expected when the surrounding features of this coal basin are considered.

One hundred feet below the bottom of the Horton run limestone outcrop, and at an elevation of 1435 feet, was found a lean, siliceous, brown hematite, loose pieces of the ore being mixed with broken pieces of coal, which probably came from one of the *Alton beds*.

The shales and slates between the coal beds, in the *Alton group*, frequently contain nodules of iron or thin seams of an iron ore, and the iron which has been found here is undoubtedly of this horizon. Analyses have also been made of the ore collected from this point. Although they show considerable iron, they are worthless as evidences of the existence of a workable bed of iron here.

It is possible to obtain selected specimens, from either this horizon or that of the *Ferriferous limestone*, in many

*So named from "*iron balls*" being found in the vicinity.

localities in Elk county, which, when analyzed, would show sufficient iron to indicate the existence of a workable bed of ore.

The strata, from which such specimens might be collected, when examined on the ground, by the most partial geologist or iron expert, would certainly be reported as not containing a workable bed of iron ore.

Fire-clay.

The *fire-clay* associated with the *Upper Marshburg bed*, between the OLEAN CONGLOMERATE above and the KINZUA CREEK SANDSTONE below, is frequently found of sufficient thickness and of desirable composition to make it a bed, from which clay can be profitably mined, for the manufacture of fire-bricks. This bed has been opened in the western part of Benezette township, between Benezette and Rock Hill villages. The openings were visited by Mr. Sheafer in September, 1879.

On the property of Judge Jones, about a mile and a half south-west of Benezette, in the eastern part of warrant 5482, a fire-clay bed was opened as early as 1854, at an elevation of 1330 feet, the elevation of Judge Jones' house being 1050 feet. It was reported that this bed had been worked by Reed and Harbison between the years 1873 and 1876. When visited in 1879, it was reported to be owned by Messrs. Harbison and Walker. The bed varies from 4 to 9 feet thick. A drift was driven into the hill for a distance of 200 feet, where the clay was found to thin down to 1 foot in thickness. Immediately overlying the clay there is a stratum of sandstone, which varies from 1 foot 8 inches to 2 feet thick, with coal smut immediately overlying it. No explorations have been made to determine the thickness or character of the coal bed. The floor of the fire-clay is composed of micaceous sandstone.

At a short distance from the clay opening, and 10 feet below it, were found blocks of conglomerate. It would appear that the Jones fire-clay lies between the KINZUA CREEK SANDSTONE and the OLEAN CONGLOMERATE. It was not possible to ascertain the top of the former rock, or the bottom of the latter.

On the hill north-east of Benezette, along the road leading to Wilson's farm, the top of the KINZUA CREEK SANDSTONE was located, at an elevation of 1445 feet. As there is a probable dip in the basin, between this latter point and the Jones farm opening, the top of the KINZUA CREEK SANDSTONE would necessarily be found at a lower height.

In the vicinity of the Jones farm the sandstone was determined to be from 50 to 60 feet thick, and the conglomerate below had about the same thickness, so that the bottom of the OLEAN would probably occur at an elevation of about 1280 feet.

A coal bed has been opened by Judge Jones about three quarters of a mile east of his house, and half a mile south of the clay bank, at an elevation of 1430 feet. Coal was dug in this locality as long ago as 35 years. About 1872 the bed was reopened, and was found to be composed of one bench of coal 2 feet 10 inches thick. The coal is bright, black, and hard, and possesses a prismoidal structure. It contains little sulphur, and was found to be of good quality, and has been used by local consumers. Where the bed was opened, there is a slight dip to the north-east; this is probably local. Above the coal is black slate and below it fire-clay. This bed is probably the representative of the *Alton Middle coal.*

Judge Jones reported that a coal bed existed below this one, which would represent the *Alton Lower bed.* The elevation of the bottom of the KINZUA CREEK SANDSTONE, in the horizon of the Jones fire-clay at this point, would be about 1370 to 1380 feet, which would show a dip in the strata between the coal bank and the clay opening.

On the warrant marked E. Lewis, on the warrantee map of this township, and a little south-east of the corner of warrant 5482, a fire-clay bed has been quarried, the bottom of the bed being at an elevation of 1610 feet. Below the bed occurs a conglomerate containing pebbles as large as hens' eggs.

Fifty feet below the bottom of the fire-clay bed, and near the head of the incline, was found red soil, which is probably derived from the MAUCH CHUNK RED SHALE No. XI. It would appear that this clay bed occurs in the same geological horizon, as the one just referred to. The similarity

of outcrops, in the two localities, would support this conclusion. If they are the same, there is a dip from the latter to the former of 280 feet, which, in the short distance between them, is exceptionally great.

This bed was first operated by E. Fletcher & Brother in 1874, Messrs. Harbison & Walker commencing to mine it in 1877. In 1879, when the opening was visited, 15 tons of clay were being mined per day. The clay at that time commanded $3 50 a ton in Pittsburgh. The clay bed varies from 2 to 6 feet in thickness, and is overlaid by black slate and coal smut, and underlaid by sandstone containing scattered pebbles.

Sixty feet above the clay bed was found the outcrop of a loose coarse-grained sandstone, which probably represents the KINZUA CREEK SANDSTONE.

The summit of the hill south-west of Judge Jones' house has an elevation of 1730 feet.

On the Lewis warrant, north of the Harbison and Walker mine, at an elevation of 1555 feet, is found Barr's *clay mine*, which previous to 1879 had been worked for about 4 years, by Barr & Radcliff. This is no doubt the same clay bed as is mined in the other localities referred to.

In 1874 Mr. Franklin Platt reported on the Jones, and Harbison & Walker (E. Fletcher) clay banks (Report H, pages 134 and 135). Mr. Platt had specimens collected from these 2 mines, which were analyzed in the Survey laboratory (by S. A. Ford).

Mr. Sheafer collected specimens from the Barr & Radcliff mine, which were analyzed by Mr. A. S. McCreath. The analyses of these specimens are as follows:

	Specimen No. 24. Jones mine.	*Specimen No. 25. Fletcher mine.*	*Specimen No. 359. Barr & Radcliff mine.*
Silica,	44.450	44.045	44.960
Alumina,	38.945	39.445	38.172
Protoxide of iron,	2.135	.940	.513
Titanic acid,	—	—	1.240
Lime,	.173	.075	.120
Magnesia,	.155	.115	.084
Alkalies,	.760	.720	.071
Sulphuric acid,	Trace.	Trace.	—
Water and organic matter,	13.287	14.138	14.840
	99.905	99.478	100.000

Specimen No. 24 is hard, compact, with conchoidal fracture and pearl-gray color.

Specimen No. 25 is very hard, compact, and of a light gray color.

Specimen No. 359 is rather hard and brittle; fracture conchoidal; color pearl-gray.

Mr. Platt, in reporting on these clays, considers them of "excellent quality," and thinks that the similarity in the two analyses which are contained in his report indicate a clay deposit of remarkable regularity. The analysis of Barr & Radcliff's clay confirms Mr. Platt's view. An excellent fire brick could certainly be manufactured from this clay.

Chapter No. XIII.

Jay Township.

Jay township lies east of Fox, south of Benzinger, west of Benezette, and north of Lawrence and Huston in Clearfield county.

With the exception of a small area in its north-western corner, which is drained by one of the head branches of Elk creek, the area of the township lies within the Susquehanna basin. Bennetts branch of the Susquehanna cuts across its south-eastern corner; streams flowing into it on both sides.

The principal streams, commencing at the north, are Trout run and its principal branches, Spring run, Little Wolf lick, Wolf lick, and Windfall run (the water from all these streams flows into the Trout run, which empties into the Bennetts branch in Benezette township, about three quarters of a mile east of the Jay line); Bell run, which falls into the Benezette a mile east of Caledonia; Caledonia run, which falls into the same stream at Caledonia; Kersey run, which joins the Bennetts branch at Weedville; and Cherry run, whose mouth is about one and three quarters miles a little west of south from Caledonia.

The principal stream which drains the south-eastern corner of the township, and which falls into Bennetts branch on its right bank, is Laurel run. Of all these streams, Trout run and Laurel run have been used most extensively by the lumbermen in floating logs into the Susquehanna.

The characteristics of the topography of this township are similar to those which have already been described as being found in Fox, east of Boons mountain, already noted under that township. These characteristics are. however, possibly more marked in Jay township than in Fox township.

In the center of the *Caledonia (Third) coal basin* there are 290 feet of COAL MEASURES overlying the JOHNSON RUN SANDSTONE, the top member of the POTTSVILLE FORMATION No. XII. These coal measures are not found in south-eastern Fox; and, from the fact that they are much softer and more easily eroded than the underlying members of the POTTSVILLE, the upper portion of the hills of Jay are more scalloped in outlines than those in Fox.

The best view of this topography, which can be obtained, is probably to be had along the road from Horse Shoe bend south-east to the Union church, near A. E. Goff's farm, and then east to Benezette village. The beauty of the scenery along this road, either in early summer or late fall, is scarcely to be exceeded anywhere else in the county.

The greatest summit in the township, which was measured, is on the road between Centerville and Caledonia, and near the point where the road crosses the line between Fox and Jay, a quarter of a mile east of W. Auman's house, sometimes marked on the local maps as the Summit House. The height here is 2265 feet above tide. In the vicinity of this summit is to be found a distinct outcrop of the MAUCH CHUNK RED SHALE No. XI. The greater height of this point, as compared with others in Jay where workable coals have been opened, has led many to suppose that workable coals could be found buried beneath it.

The "*Big bed*," which is found in Caledonia run immediately below A. E Goff's place, is the representative of the *Clarion bed.* The elevation of the coal bed is 1420 feet, or 845 feet lower than Auman's summit, which latter, on account of the upward dip of the coal bed to the north-west, would have to be at least 200 feet higher, in order to contain it.

The lowest point in the township is where the Bennetts branch crosses the line into Benezette near Rockville, at an elevation of 1110 feet above tide. The distance between the lowest and highest points is about 7.5 miles, in an air-line, and the difference in height is 1155 feet, which is the most rapid average descent per mile, for the distance named, that I measured anywhere in the county.

Jay lies almost entirely within the *Third Bituminous coal basin*, which is the same basin in which the Cameron county mines are located, to the north-east. The north-eastern end has been locally designated as the *Cameron basin*, and the south-western end as the *Caledonia basin*, the former name being assigned to the basin, from the fact that the only mining operations being carried on within the confines of Cameron county are those of the Cameron Coal Company; and the latter, because one of the best explored sections of the coal measures, contained in the basin in the south-western portion, is at Caledonia.

The axis of this basin has a direction, in the township, nearly due north-east and south-west, passing through the cross-roads at Weedville, and crossing the Caledonia run about half a mile north-west of the village. This is on the assumption that the axis of the basin is straight, as represented on the map, (Plates I and II in the Atlas.) That the direction of the center of the basin is absolutely straight, as represented, is very questionable; in fact, from an examination made upon the dips both in Jay and Benezette, it would appear that it is not straight. A sufficient number of dips could not be obtained, however, to locate it with absolute precision, but the line, as drawn on the map, will probably locate it sufficiently close for all practical purposes.

The *Boons Mountain anticlinal* crosses the north-western part of the township, through Auman's summit, in a direction very nearly parallel to the axis of the coal basin. The dips of the measures, both south-east and north-west, toward the axes of the synclinals, are very rapid. Coincident, however, with these dips in the strata, the slope of the surface is rapid, so that the areas of the coal basins are extremely limited, as compared with those in the *Fourth basin*, particularly in Fox and Horton townships.

The strata outcropping in the township embrace those included between the upper part of the MAHONING SANDSTONE, at the top of the LOWER PRODUCTIVE COAL MEASURES, and the middle portion of the POCONO SANDSTONE No. X, ex-

posed along the Bennetts branch, in the vicinity of the line separating Jay and Benezette.

A compiled section, representing the general structure of the PRODUCTIVE COAL MEASURES and POTTSVILLE CONGLOMERATE No. XII, for Benezette and Jay townships, is practically the same. It is as follows* (Fig. 79, page 268):

1. Sandstone and shale,	100′	
2. Black slate,	5′	
3. Concealed,	30′	
4. Fire-clay,	2′	
5. Black slate,	5′	
6. *Kittanning Upper coal bed,*	2′	6″
7. Fire-clay and shale,	5′	
8. *Limestone, Johnstown cement bed,*	2′	
9. Ferruginous shales,	60′	
10. *Kittanning Lower coal bed,*	1′	6″
11. Sandstone and shale,	15′	
12. Ocher clay and iron ore,	3′	
13. *Ferriferous limestone,*	5′	
14. Slate and shale,	34′	
15. *Clarion coal bed,*	5′	3″
16. Sandstone and shale, JOHNSON RUN SANDSTONE,	60′	
17. *Alton Upper coal bed,*	2′	6″
18. Shale,	8′	
19. *Alton Middle coal bed,*	3′	6″
20. Fire-clay and shale,	12′	
21. *Alton Lower coal bed,*	2′	4″
22. Sandstone and shale, KINZUA CREEK SANDSTONE,	55′	
23. *Marshburg Upper coal bed,*	—	
24. Sandstone and conglomerate, OLEAN CONGLOMERATE,	60′	
25. MAUCH CHUNK RED SHALE, No. XI,		
Total,	478′	7″

The upper portion of this section, above the *Ferriferous limestone*, is constructed largely from observations made along the upper portion of Caledonia run, south-east of the cross-roads at A. E. Goff's and the Union church, in warrant 4906.

The largest coal area in the township is that lying between Spring creek, Kersey run, and the Bennetts branch, which

* This section is given under the description of the geology of both townships, for convenience of reference for those readers in the district who may wish to inform themselves as to the geology of their own township, without referring to the text relating to the other township, with which they may not be familiar (See section 75, page 244, and 79, page 268).

JAY TOWNSHIP.

Fig. 79. p. 267.
Benezette and Caledonia.

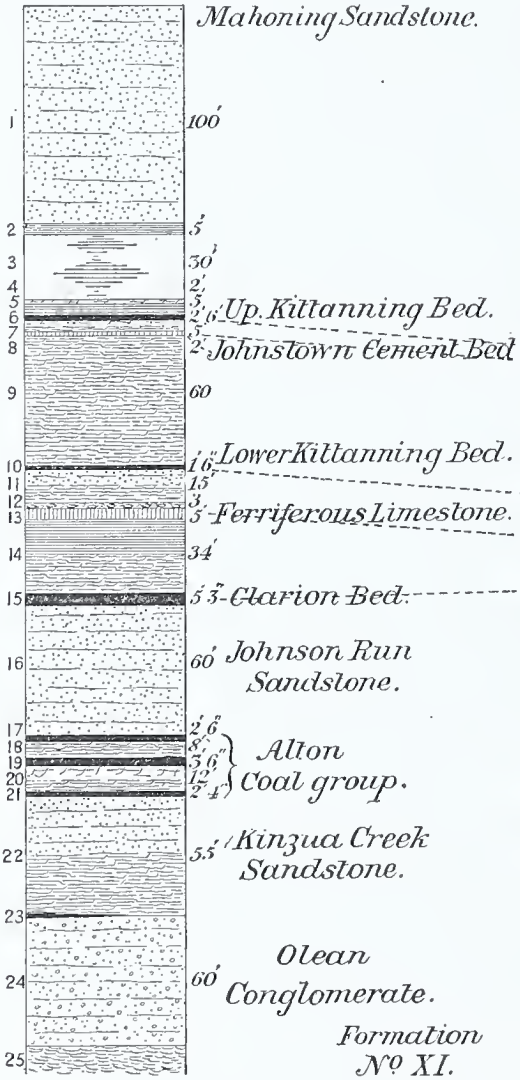
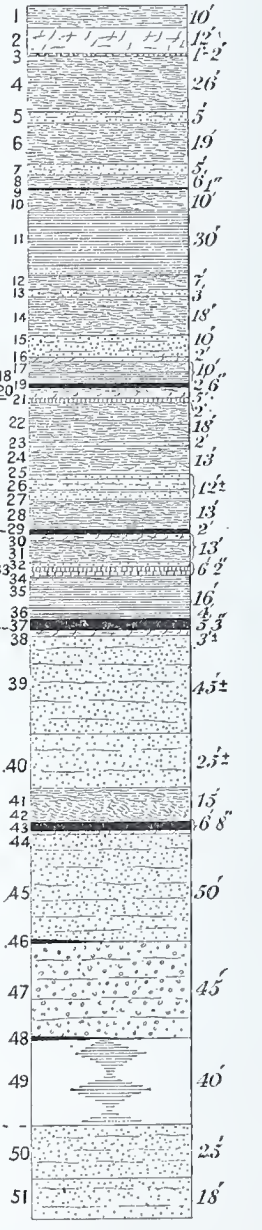


Fig. 80. p. 270.
Section in Caledonia Basin Jay Township.



100′ = 1″

is locally known as the *Caledonia basin.* This area is approximately defined on the geological map, (Plate II.) The rapid dip of the strata toward the south-east, and the imperfect map of the streams, prevented an exact mapping of the outcrops.*. The great dip is shown by the following facts: On Caledonia run *Goff's "Big coal bed"* outcrops at an elevation of 1420 feet. Over the *Boons Mountain anticlinal*, at the Horse Shoe bend, the restored position of this coal bed would be found at least 200 feet above the present surface, or at an elevation of about 2470 feet. The horizontal distance, between these two points, is about five miles (air line), and the vertical distance, between the coal bed outcrop on Caledonia run and the restored position of the coal bed over the anticlinal axis, would be 1050 feet, showing a dip at an average rate of 210 feet per mile. From observations made on the strata between the two points, it would appear that the rate of dip between Horse Shoe bend and P. L. Gardner's place is greater than between this latter point and the coal outcrop on Caledonia run.

The determination of the dip in this locality has been a valuable aid in the identification of the coal bed outcrops in the vicinity of Gardner's and Spangler's farms, in warrant 4845. The computed elevation of the *Clarion bed* on the Spangler farm, based on the dip of the strata, was 1750 feet, whereas the actual elevation of the opening of this bed at the head of Spring run, as determined by the barometer, is 1720 feet.

One of the best exposed sections in the neighborhood of the Bennetts branch in Elk county is that along Caledonia run. When I measured this section,† the bed of the stream had been cleaned out by the recent heavy rains, so that the opportunity for observing the stratification was exceptional. The intervals, where no outcrops were found, rarely exceeded a few feet, and, in these cases, the character of the pieces of broken rock resembled so closely the outcrop of the overlying stratum that, in constructing the section, I have not

*The geology, as outlined on the county map, is sufficiently accurate for general descriptive purposes.

† August 21, 1878.

noted the intervals, but have presumed to record the character of the rock which it is believed composes them.

The elevation of the summit of the hill at the head of Caledonia run was determined to be 1710 feet, or 35 feet higher than A. E. Goff's barn near by. From this point the measurements were continued down the run to the Caledonia (R. R.) tunnel, the elevation of which is 1148 feet.

On account of the dip being to the south-east, from Goff's to where the run intersects the axis of the coal basin, about half a mile north-west of Caledonia village, the columnar thickness of the strata between the summit and the center of the basin would not be as great as the difference in the elevation of the strata, outcropping at these two points. A partial allowance has been made for this dip, but, as it was impossible to ascertain the dip with any precision, the thicknesses of the strata, as indicated in the section, may need a slight adjustment, before they can be accepted as a final statement. The correction, however, cannot be made, until the exact dip is determined, through mining operations which may ultimately be carried on in the coal beds found in the run; this correction would probably be so slight that, for all practical purposes, the section, as given below, can be accepted as a final record.

From the top of the section, at an elevation of 1710 feet, to the bottom of the *Clarion coal bed* at *Goff's Big vein opening*, in the run, at an elevation of 1420 feet, a very slight correction has been made in the thickness, so that the vertical position of any one stratum, as given in the section, can be relocated on the ground, by calculating the rock thickness between the summit and the desired stratum, and laying this distance off by leveling. The Caledonia Run section is as follows (Fig. 80, page 268):

1. Gray and yellow argillaceous shale, ... 10′
2. Fire-clay, ... 12′
3. Iron ore, ... 1′ to 2′
4. Yellow argillaceous shale, ... 26′
5. Gray sandstone, ... 5′
6. Gray shale, ... 19′
7. Massive knotty ferruginous sandstone, containing plant fossils, ... 5′

8. Ferruginous shale,		6′	
9. *Coal bed*,			1″
10. Gray and olive ferruginous shale,		10′	
11. Dark gray and black slate,		30′	
12. Gray and olive shale,		7′	
13. Shaly sandstone, stained with bituminous matter and iron,		3′	
14. Yellowish-gray argillaceous shale,		18′	
15. False-bedded flaggy micaceous sandstone,		10′	
16. Soft fire clay,		2′	
17. Gray shale,		5′	
18. Black slate,		5′	
19. *Upper Kittanning coal bed*,		2′	6″
20. Gray shale and fire-clay,		5′	
21. Bluish-gray cherty limestone, *Johnstown cement bed*,		2′	
22. Gray and olive shale,		18′	
23. Ferruginous argillaceous shale,		2′	
24. Gray shale,		13′	
25. Dark gray micaceous sandstone,		2′	
26. Ferruginous sandstone,		5′±	
27. Dark gray slate, containing thin bands of micaceous sandstone,		5′±	
28. Gray shale,		13′	
29. *Lower Kittanning coal bed*,		2′	
30. Gray sandy fire-clay,		3′±	
31. Gray and olive shale,		10′	
32. Hard gray fine-grained sandstone,		2′	
33. Argillaceous ferruginous limestone,	*Ferriferous limestone*,	2′	
34. Hard gray limestone,		2′	2″
35. Gray slate, iron stained,		16′	
36. Black slate,		4′	
37. *Clarion coal bed*, (*"Goff's Big vein"*),		5′	3″
38. Hard fire-clay,		3′±	
39. Hard gray massive coarse-grained ferruginous sandstone,	JOHNSON RUN SANDSTONE,	45′±	
40. Hard gray massive fine-grained sandstone,		25′±	
41. Gray ferruginous shale and clay,		15′	
42. Black slate,			10″
43. *Alton Middle coal bed*,		3′	10″
44. Hard fire-clay,		2′±	
45. KINZUA CREEK SANDSTONE,		50′	
46. *Upper Marshburg coal bed*,		—	
47. OLEAN CONGLOMERATE,		45′	
48. *Lower Marshburg coal bed*,		—	
49. Interval (No. XI),		40′	
50. Gray massive sandstone,	(No. X),	25′	
51. Shaly sandstone, false-bedded, Caledonia R. R. tunnel.		18′	
Total,		561′	8″

A comparison of this section with others in Elk county reveals marked differences, in the stratigraphy, which are worthy of notice, since they affect the value of the coal lands in the different sections, for mining purposes. This comparison may be more readily made by reference to the sheet of general coal sections contained in the Atlas (Plate VII).

There seems to be but little doubt, that the shale and sandstone, at the top of the Benezette-Caledonia section, is the representative of the MAHONING SANDSTONE, the same stratum which is shown at the top of the Horton and Brockwayville sections. If this conclusion, which seems now to be borne out by the facts, which can be at present obtained, shall be proved beyond question, by more detailed examinations which may be made in the future, it would indicate that there is little probability of the *Freeport coal beds* ever being found in the *Caledonia basin*, certainly not of workable dimensions.

The interval between the *Johnstown cement bed* and the MAHONING SANDSTONE, in the *Caledonia basin*, is thinner than at Brockwayville or in Horton township.

The Caledonia section above the Upper Kittanning coal was replete with exposures, but I saw no indication of any coal in it, except at one point, at an elevation of 1625 feet, where a thin seam of coal, only 1 inch thick, was located. It would be presumption, however, to assert that no coal exists in this portion of the section, except this small layer, because the intervals, found here and there, of a few feet in height, where no outcrops were seen, *might contain* thin coal beds. If such beds do exist, it would seem probable that pieces of coal or smut would be found in the bottom of the run. None such, however, were seen.

Prof. Rogers,* in referring to this section, says: "In the 400 feet of coal measures occur 6 distinct seams of coal, 3 of these possessing sufficient thickness to be valuable. There are likewise 3 or 4 beds of limestone, and some layers of shale rich in iron ore."

*Final Report, Vol. II, page 484.

In explanation of the number of coal beds reported in this section, I believe that the outcrops of the same beds were visited in different localities. Unless allowance be made for the strong dip, which exists in this vicinity, the outcrops of one coal bed, found in different places at various elevations, might be mistaken for those of different coal beds.

The absence of the representatives of the *Freeport coals* in the *Caledonia basin* may be explained in three ways: (1) at the time that the vegetation was growing, which ultimately formed these coal beds in portions of the *Third basin*, the area, now embraced within the *Caledonia basin*, may have been so high, above the surface of the surrounding water, that the conditions were not such as were favorable to a vegetable growth; or, (2) the same surface may have been very much below water level; or, (3) vegetation may have grown in the horizon now occupied by each one of the *Freeport coals*, and, before it could be buried by superincumbent sediments, it may have been eroded. This latter hypothesis, however, I think the most improbable of the three.

The *Clarion* and the *Alton Middle coal beds*, which were found to be the thickest and to contain the best coal, of those examined in Benezette township, are the most important of any of the coal beds which have as yet been opened, and which I examined in Jay.

The *Clarion bed* was opened in September, 1871, by Mr. A. E. Goff, in Caledonia run, at what is now known as the "*Goff's big vein opening.*" The elevation of the bottom of the bed, at this opening, is 1420 feet, and the bed measures 5 feet 3 inches in thickness. This bed, at the time that the First Survey was made, had been opened on the outcrop, and was known as the *Warner coal*. Prof. Rogers reports it to be 5 feet thick, and gives the following analysis of the coal:

Volatile matter,	37.00
Coke,	63.00
Ash,	8.50

Reference is made to this coal bed by Mr. Platt, in Report 18 RR.

H (page 138), accompanied by a section of the coal measures in Caledonia run, by Mr. Young. There is a general agreement between this section and that already given.

Mr. Goff reports, that he has opened this same coal bed on a 300 acre lot on a branch of Spring run, in the northern part of warrant 5030, where the bed measured 5 feet thick; two seams were reported to exist on the same lot below the *Clarion bed.* This locality, however, was not visited with Mr. Goff. It is probable that the opening to which he refers may be one of those which I visited in the vicinity of Denison's.

The *Middle Alton coal bed* has been opened in Caledonia run below the Goff opening, the difference in elevation between the bottoms of the two coal beds being 115 feet. The opening had fallen shut when I visited it, but the thickness of the coal bed, was reported to me to be 3 feet 10 inches. Mr. Petriken was working this bed, which is generally called the "*Four Foot bed,*" in 1874, and specimens of the coal at that time showed, on analysis * (A. S. McCreath):

Water,	1.770
Volatile matter,	32.170
Fixed carbon,	59.323
Sulphur,	2.067
Ash,	4.670
	100.000
Coke, per cent.,	66.06
Color of ash,	reddish brown.

The coal has a dull luster, is very friable, is coated with silt, and contains considerable pyrites.

In Rogers' Final Report this bed is named the "*Three Foot bed,*" † and the following analysis of it is given:

Volatile matter,	38.200
Coke,	61.800
Ash,	7.200

Although a coal bed was not found immediately above or below this one, there seems to be very little question about its identity with the bed opened on Wilson's farm in Ben-

* Report H, page 138.

† See Report H, page 139.

ezette township and elsewhere, which is the representative of the *Alton Middle coal bed.*

As far as developments have been made in Caledonia run, the *Clarion* and *Alton Middle beds* are the only ones which can be expected to produce merchantable fuel, and upon which any mining operations carried on in this locality must depend.

The *Ferriferous limestone* is well exposed in the Caledonia run. The elevation of the bottom of the stratum, which is 2 feet 2 inches thick, is 1450 feet. The upper stratum, which is 2 feet thick on the outcrop, is a very argillaceous limestone, containing considerable iron. It easily weathers and forms an ocherous clay. This upper stratum has been mistaken for an iron ore. Two specimens were sent to the Survey Laboratory for analysis. Both proved to be limestones heavily charged with iron. The analyses (S. A. Ford) yielded:

	*Specimen No. 9.**	*Specimen No. 10.**
Sulphur,	.118	Trace.
Phosphorus,	.072	.031
Carbonate of lime,	66.912	36.764
Carbonate of magnesia,	9.836	2.011
Insoluble residue,	16.130	53.330

No. 9 is a hard, compact limestone, minutely crystalline, with conchoidal fracture, of bluish-gray color, and showing crystals of pyrites.

No. 10 is a hard, compact limestone, exceedingly siliceous, and of bluish-gray color.

The road ascending the hill in a northern direction from Caledonia, and connecting the county road along Bennetts branch with the Benezette road near J. Ovel's, passes over a summit, 1620 feet high, but a short distance from Caledonia. Along the road, in the bed of the east fork of Caledonia run, to the west of the road, are several openings on coal beds and a number of coal outcrops.

Starting from the Morey house, in Caledonia, at an elevation of 1138 feet, the first coal outcrop was seen at an elevation of 1165 feet. The outcrop was a very insignificant

* For number of specimen see Report M, page 77.

one, but sufficient to indicate the existence of a small coal bed, which I have taken to be the representative of the *Lower Marshburg coal*, a very sporadic bed frequently found in the lower part of the OLEAN CONGLOMERATE, or in a black slate which sometimes occurs immediately under the OLEAN ROCK.

At an elevation of 1245 feet, a small coal outcrop was found, which is probably the representative of the *Upper Marshburg bed.*

On the south side of the road, at an elevation of 1300 feet, an opening on the *Alton Middle (?) coal bed* was made by Mr. Reuben Winslow, in 1874. The bed at this point is 4 feet thick, and has a black slate roof and fire-clay floor. The coal mined from here is hard, has a bright luster, and cubical fracture. An outcrop of the same bed was found in the run, at an elevation of 1290 feet. These two outcrops are north-east of the opening in Caledonia run and at very nearly the same height, the elevation of the bottom of the bed in Caledonia run being 1305 feet. An interval, from 15 to 20 feet, under these outcrops, seems to be occupied by gray argillaceous shale and black slate, both of which are very much stained with iron. These strata probably form the lower part of the *Alton group.*

The outcrop of the *Clarion bed* has been dug into on the road, at an elevation of 1400 feet, or 20 feet lower than the bottom of *"Goff's Big vein opening"* in Caledonia run. Where the outcrop of the bed was dug into considerable coal was found, but none of the strata seemed to be in place.

Sixty five feet above this outcrop, at an elevation of 1465 feet, a coal outcrop was located along the road. This is, without doubt, the representative of the *Kittanning Lower bed.*

Near the Petriken shanty, a coal outcrop is seen in the road, at an elevation of 1585 feet. This is the representative of the *Kittanning Upper bed.*

The summit of the hill east of Petriken's shanty has an elevation of 1620 feet. This summit is capped by strata about 140 feet lower, geologically, than the summit near Goff's barn, at the head of Caledonia run. This fact would

indicate a rather rapid dip south-west, in the direction of the synclinal axis of the *Caledonia basin.*

The rock outcrops found along the road, in the valley of the eastern fork of Caledonia run, are so few, that it was not possible to construct a vertical column of strata along either line. The few outcrops which were located, together with their barometric elevations, are given below, in a copy of my field notes. This may be of use to future observers who may be successful in finding other outcrops to fill out the lacunæ.

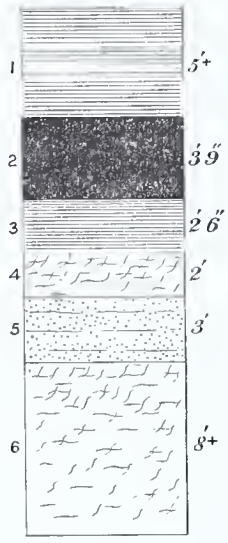
Outcrops observed along road between Caledonia and J. Ovel's, and in bed of the east fork of Caledonia run.

1138′ Morey House.
1165′ *Coal outcrop* (*Lower Marshburg bed*)
1180′ Sandstone.
1200′ *Coal outcrop* (?).
1230′ Hard massive greenish-gray sandstone.
1240′ Flaggy sandstone and sandy shale, micaceous.
1245′ *Coal outcrop* (*Upper Marshburg bed*).
1265′ Gray shale and gray and black slate.
1280′ Gray shale very much stained with iron.
1285′–1290′ *Coal outcrop* in run.
1300′ *Reuben Winslow's coal opening*, south side of road. } (*Alton Middle* (?) *bed.*)
1310′ Gray and black shale and flaggy sandstone.
1330′ Flaggy sandstone and dark gray shale stained with iron, alternating with occasional seams of hard massive sandstone.
1335′ Hard massive and flaggy sandstone, micaceous.
1345′ Hard black slate containing plates of *coal.*
1365′ Gray shales.
1380′ Hard dark-gray massive sandstone, micaceous.
1400′ *Coal outcrop* (*Clarion bed.*)
1450′ Hard massive sandstone.
1465′ *Coal outcrop* (*Lower Kittanning bed*).
1510′ Hard massive sandstone.
1585′ *Coal outcrop* (*Upper Kittanning bed.*)
1620′ Summit east of Petriken's old shanty.

The elevations given are those of the bottom of the outcrops: no note has been made of the vertical extent of the individual outcrops; in most cases they varied from 2 to 5 feet.

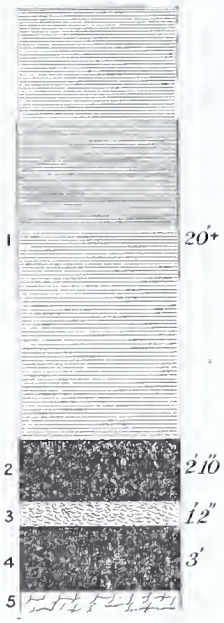
Along the Benezette and Ridgway turnpike, between Benezette and J. Ovel's place, near the eastern line of warrant 5030, a number of coal beds have been opened. As nearly as

Fig. 82. p. 281.
Upper Alton Bed
Dill's Saw Mill opening.



10' = 1"

Fig. 81. p. 279.
Clarion "Split" Bed near Benezette.



10' = 1"

Alton Upper Bed.
" Middle "
" Lower "

Undescribed interval of Kinzua Creek S.S. Olean Congl., Mauch Chunk No. XI, and Pocono. No. X.

Fig. 83. p. 282.
Clarion Bed
Spangler opening.

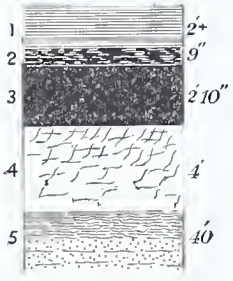
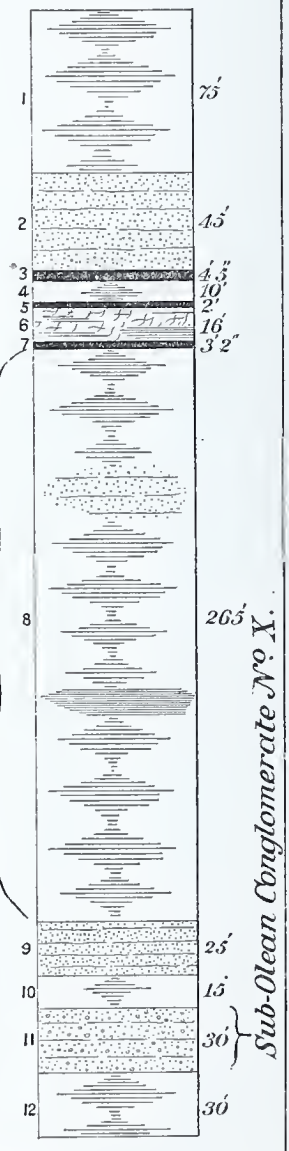


Fig. 84. p. 291.
Irwins Mills.



100' = 1"

could be determined, the axis of the *Caledonia basin* crosses the pike about half a mile east of the latter locality.

The dip of the strata from Benezette to the center of the basin is in a direction north-west, and quite rapid, possibly at an average rate of 150± feet per hundred. On account of this rapid dip, and the few outcrops which were located, one above the other, it was not possible to construct a columnar section, showing the thickness of the strata between the individual coal beds; the identity of the coal beds, which I have indicated below, is not placed beyond a doubt.

Not far east of the line separating Jay from Benezette, a coal bed was opened on its outcrop, to the north of the road, which showed a thickness of 2 feet 10 inches. The elevation of the opening is 1390 (?) feet, or about 350 feet above the village of Benezette. A quarter of a mile beyond this point, at an elevation of 1485 feet, a little to the north of the road, a coal bed was opened, which is known locally as the "*Split bed*," from the fact that it is composed of two distinct benches of coal of very nearly equal thicknesses, with about 1 foot of clay separating them. The section of the bed, as I measured it near the outcrop, was as follows (Fig. 81, page 278):

1. Ferruginous black slate, (roof,)	20′+
2. *Coal*,	2′ 10″
3. Clay,	1′ 2′
4. *Coal*.	3′
5. Fire-clay, (floor,)	—
Total,	27′

The latter bed is the representative of the *Clarion bed*, or "*Goff's big vein*," and the former the representative of the *Alton Middle bed*, or the lower coal opened on Caledonia run, at an elevation of 1305 feet.

A quarter of a mile from Squire A. W. Gray's, a limestone bed (*Johnstown cement bed*), which is the same as the upper limestone on Caledonia run, has been opened. Immediately above the limestone, some coal smut was found, which must come from the outcrop of the *Kittanning Upper bed*. No explorations have been made at this point for this coal bed, so that nothing is known as to its thickness or character.

A coal, which is probably the representative of the *Freeport Middle bed*, has been dug into along the road east of Squire Gray's house, at an elevation of 1685 feet, which showed a face of 2 feet of coal. It was, however, not solid or under roof, so that the actual thickness of the bed could not be judged from this. The same bed has been dug into, on the outcrop, back of Squire Gray's house, at an elevation of 1695 feet, and, as far as dug into, showed a thickness of 2 feet 4 inches.

The summit in the road west of Squire Gray's house is 1800 feet high, and is capped by a member of the MAHONING SANDSTONE.

In Mr. Lesley's sections (see page 251) is given a section of the strata, as he observed them under this summit. Certain features are shown in this section, which were not determined by myself. The limestone which Mr. Lesley notes is, without doubt, the *Ferriferous limestone*, and the coal bed overlying it the *Lower Kittanning*. Neither of these strata were located. The coal bed near the upper part of his section, having a thickness 2 feet 10 inches, is undoubtedly the same coal as that which I located back of Squire Gray's house, at an elevation of 1695 feet. Lesley's *coal bed "D"* is the same as the *"Split bed"* referred to above, and his *coal bed "C"* is probably the same as the *Alton Middle bed*, and if so, there should be the "place of" one coal bed above it and the "place of" one coal bed below it.

The top of the conglomerate, as noted in Lesley's section, is probably the top of the OLEAN CONGLOMERATE, and not the top of No. XII.

Going west from J. Ovel's house, along the pike, a comparatively great south-eastern dip in the strata is encountered. At the cross-roads, near the head of the small branch of Spring run, in the south-western corner of warrant 5030, the elevation is 1475 feet, and at Dill's saw-mill, about a mile north of this point, the elevation is 1460 feet. There is every evidence that at this latter point the surface is immediately underlaid by the lower part of the OLEAN CONGLOMERATE, or the representative of the MAUCH CHUNK RED SHALE No. XI.

A coal bed has been opened half a mile south-west of V. Denison's house, near Dill's saw-mill, at an elevation of 1560 feet. A section of the bed and associated strata is as follows (Fig. 82, page 278):

1. Black cannel slate, (roof,)	5′+
2. *Coal*,	3′ 9″
3. Cannel slate,	2′ 6″
4. Fire-clay,	2′
5. Hard ferruginous sandstone,	3′
6. Fire-clay,	8′+
Total,	24′ 3″

Iron balls are frequently found in the roof slates. The coal has both a cubical and columnar fracture, and is hard to mine, although blasting has never been resorted to. This bed is the representative of the *Alton Upper*.

A point, which marked, apparently, the top of a massive sandstone and conglomerate, back of Dill's house, at an elevation of 1535 feet, is probably at the horizon of the top of the KINZUA CREEK SANDSTONE.

The elevation of the road forks, about a quarter of a mile west of J. Robinson's, near the center of warrant 5029, is 1505 feet. North of the road between Robinson's and Dodge's places, and on a little run, a coal bed has been opened, at an elevation of 1505 feet, which is undoubtedly the same as the *Denison bed*. The outcrop of a bed was found about 30 feet below this coal, which is probably the representative of the *Alton Lower bed*.

An idea can be had as to the dip of the strata in this portion of the *Caledonia basin* from the following facts. The elevation of the top of the OLEAN CONGLOMERATE at the Harbison & Walker (Fletcher) clay bed opening is 1610 feet. The estimated elevation of this same horizon at Squire Gray's is about 1400 feet. The distance in an air-line between the two points is about a mile and a half, which would make the average dip toward the north-west about 150 feet per mile. From Denison's to the center of the basin east of Ovel's, a south-eastern dip is probable, at the rate of from 175 to 200 feet per mile.

South of John Hess' house, in the north-eastern part of

warrant 4845, both the *Clarion bed* and the *Alton Upper* (?) *bed* have been opened. The openings, however, had fallen shut at the time that I visited them. The *Clarion bed* was opened at an elevation of 1745 feet, about 600 feet south-east of Hess' barn; the bed is reported by Mr. Denison to have been 4 feet in thickness. The drift at this opening went in on the dip, which is south-east, and had to be abandoned, on account of water. The bed is immediately overlaid by a black slate, containing kidney ore. This slate is probably 4 or 5 feet in thickness. Below the bed occurs a fine-grained argillaceous sandstone, which is part of the JOHNSON RUN ROCK, the top of the POTTSVILLE CONGLOMERATE No. XII. The *Alton Upper* (?) *bed* was opened at an elevation of 1665 feet. Twenty feet below this opening, a crop was found in the road, which is the outcrop either of this bed or the *Alton Lower bed.*

The elevation of P. L. Gardiner's house, near the cross-roads, in the northern part of warrant 4845, is 1845 feet. In the road opposite Gardiner's barn, the outcrop of a coal bed may be seen, which is probably the representative of the *Clarion bed.*

The elevation of the road in front of M. Spangler's house is 1790 feet, and in one of the head branches of Spring run below his house, the *Clarion coal bed* has been opened, at an elevation of 1720 feet. A section, measured near the outcrop, is as follows (Fig. 83, page 278):

1.	Dark gray slate stained with iron,	2′+
2.	Black slate and bony *coal*,	9″
3.	*Coal*,	2′ 10″
4.	Fire-clay,	4′
5.	Gray shale and sandstone, (JOHNSON RUN SANDSTONE,)	40′+
	Total,	49′ 7″

The coal is bright, has a cubical fracture, and is said to be a favorite fuel among the local consumers. It burns easily, and produces a fine gray ash and no clinker. This opening was made by Mr. John S. Brockway* about forty years ago, and the coal has been mined more or less exten-

*I am informed that Brockwayville, in Jefferson county, was named after Mr. Chauncey Brockway, a brother of John S. Brockway.

sively for twenty years past. During the years immediately preceding 1878 I am informed that from 1000 to 1500 bushels a year were mined, and sold for five cents a bushel. The coal has been hauled by consumers as far as Caledonia and Weedville.

On the road descending from A. E. Goff's house, near the Union church, to Weedville, the elevation of John Thomas' old log house was found to be 1690 feet, and the elevation of the road in front of the old house marked "R. W." on Beer's county map, at the sharp turn in the road, in the eastern part of warrant 4891, is 1640 feet.

About a mile and three quarters from Goff's, and half a mile above Weedville, at an elevation of 1310 feet, the *Alton Middle bed* has been opened at what is known as the *Turley mine*. The bed contains 3 feet 6 inches of good clean coal, with 6 inches of poor sulphurous coal on top, which is not mined. A black slate overlies the bed, and forms a good solid roof.

The JOHNSON RUN SANDSTONE, above the Turley mine, is composed of a rather fine-grained flaggy sandstone. There is quite a decided terrace between 70 and 80 feet above the floor of the Turley drift, where, I was informed by the miner, a bed had been opened at one time which measured 5 feet thick. No outcrop of such a coal was found, but it is probable that the bed exists, for the point indicated is about the horizon where we might expect to find the *Clarion bed*. Between 20 and 25 feet below the drift, the outcrop of a coal bed was found in the road.

About 1000 feet north of the Turley drift, an abandoned coal opening was located, at an elevation of 1330 feet. A black slate outcrops above the coal, but the coal itself was not seen. This is considered by the miner at the Turley drift to be an overlying bed. It is currently reported that this bed is 3 feet thick, and that a bed outcropping below the road in the Turley drift is 6 feet thick. As to the correctness of this information, I have no facts, in the immediate vicinity, to enable me to judge. The elevation of the Weedville cross-roads is 1175 feet.

A number of coal beds have been opened near the head

waters of Laurel run, along the line separating Jay township from Clearfield county. Although considerable prospecting has been done here and a number of seams located, as far as I am informed, no coal has been mined for shipment. The elevation of the top of an old bridge, which crosses Laurel run about three miles and a half from Caledonia, is 1275 feet, and the elevation of Laurel run at Barrow's old lumber camp,* which is about four miles from Caledonia, near the county line, is 1260 feet. But a short distance from this camp, and at an elevation of 1535 feet, a pit was dug on the outcrop of a coal bed by Barrows. Although no coal was seen at this point when I visited it (September 26th, 1879), I am informed by Levi Bateman that coal was taken out. If a seam actually exists here, it is probably the representative of the *Upper Marshburg bed.* A sandstone was found outcropping above the bed, which resembles the KINZUA CREEK ROCK.

In 1876(?) Patrick Burke, James Cummins, and Levi Bateman opened a drift in a coal bed, at an elevation of 1605 feet. The bed was 2 feet 6 inches thick, at the head of the drift, and the coal hard and cannelly. A hard ferruginous sandstone was found above the drift, which is probably the representative of the JOHNSON RUN ROCK, and the bed is probably one of the ALTON GROUP COALS. A prospect pit, looking for coal, was sunk a few feet above the bed, at an elevation of 1635 feet. Nothing was found, however, but gray argillaceous shale and ferruginous sandstone, resembling that outcropping above the coal drift, just noted.

At an elevation of 1715 feet a pit was sunk to a coal bed, which, I am informed, measured 5 feet thick. The opening had fallen shut when I visited it, so that the face of the bed was not seen. The rock above the bed consisted of a ferruginous sandy shale and slate. The elevation of the bottom of the bed was 1700 feet. This bed is doubtless the representative of the *Clarion* or "*Goff's big vein.*" Goff's opening is distant about four and a half miles due north. The dip of the strata in this distance is nearly 300 feet, or at an average rate of about 65 feet to the mile. This does not, how-

*Abandoned in 1875. (?)

ever, represent the maximum dip of the strata on the eastern side of the *Caledonia basin*, since the maximum dip is nearly in a north-west direction. The county line lies very near this opening. The elevation of the summit above the opening is 1870 feet.

Descending the hill to the south-west of the Elk-Clearfield county line, along which the ascent was made, a coal bed has been opened on the outcrop, at an elevation of 1740 feet, which is probably the *Lower Kittanning bed.*

The *Clarion bed* was drifted on at an elevation of 1690 feet. The opening had fallen shut when I visited it. The coal found at the mouth of the drift was hard and dry, and had both a columnar and cubical fracture, resembling very much that opened at Wilson's bank in Benezette. Levi Bateman reported that the bed here measured 5 feet thick. The outcrop of the OLEAN CONGLOMERATE is to be seen further down the hill. The larger pebbles vary from the size of a hickory nut to that of a hen's egg.

At an elevation of 1350 feet, near a summit in the road leading from Barrows' camp to Caledonia, a bog iron ore was found. which probably was derived from the deposition of the iron dissolved out of the lower part of the POTTSVILLE CONGLOMERATE and the shales immediately underlying the bottom member (OLEAN CONGLOMERATE), which are frequently very ferruginous. This deposit is one of a number to be found in the township, which are, however, of no economical importance, as the ore is not sufficiently pure to render it of any value for the manufacture of iron.

Chapter No. XIV.

Highland Township.

Highland is east of Howe and Jenks in Forest county, south of Wetmore in McKean, west of Jones and Ridgway, and north of Spring creek. The greater and southern portion of its surface is drained by the head branches of Spring and Bear creeks, which empty into the Clarion River within Spring Creek township.

The most northern part, about one fifth of its entire area, is drained by the south branch of Tionesta creek, which flows first west within the township, then north-west into Warren county, making an abrupt horse-shoe bend at Old Sheffield village. Afterwards it flows south and then south-west through Forest county, emptying into the Allegheny River at Tionesta village.

The probable existence of north and south fractures or fissures in the rocks, determining the south flow of a number of the branches of Bear creek, and of one head branch of Spring creek, is referred to (pages 122 and 290) in the descriptive chapters on Ridgway and Spring Creek townships, respectively.

The topography is not unlike portions of the surrounding townships, except that the broad flat summits are the more prominent features; the name of the township itself is suggestive of the character of the surface contour. The average height of its surface is greater than in any other township: it is in fact the *highland* of Elk county.

The "*big level*" *ridge*, which extends from Tylersburg in Clarion county to Howard hill in McKean county, and along which the narrow gauge railroad has recently been built, extends through the northern part of the township. Its elevation along the railroad varies from 1912 feet, at the Forest-Elk line, to 2071 feet. Spring Creek summit, about

in the center of the township, between the headwaters of Spring creek and Bear creek, has probably a greater elevation than any other point in the township.

The topography of this township, to one journeying through the woods, seems very confused and intricate, due probably to three causes: (1) the dense forests, which cover the surface of this township more generally than that of any other township, and which serve to obscure very much the surface contour; (2) the close proximity to one another of the heads of the streams, which flow in all possible directions; and (3) the slopes from the summits into the valleys being so gradual that one imperceptibly makes a descent into the valleys in any direction from the summits of the hills. Even a woodsman of considerable experience, if not acquainted with the local topography, may proceed in a course directly opposite to that intended, unless closely following his compass. In fact, I have been with such, on cloudy days, when the accuracy of their compass was questioned, when reference was made to it after a considerable interval of time.

The lowest point in the township is, without doubt, where Bear creek crosses the southern line into Spring Creek township, although the elevation of this point was not absolutely determined.

The south-eastern portion of the township is crossed by the *Fifth anticlinal axis*. The dips from this axis in a north-western direction are hardly perceptible. Those from it south-east toward the axis of the *Fifth coal basin* are very much greater, ranging from 25 to 50 feet per mile; the greater dips existing where the anticlinal axis crosses the branch of Bear creek heading in the vicinity of Highland.

The elevation of the cross-roads, at the school-house in Highland, (warrant 3776,) is 1850± feet, and of Bear creek, at the Warren-Ridgway turnpike crossing, 1825± feet.

A coal outcrop was located in the western part of warrant 3776, about half a mile from the school-house, at an elevation of 1900 feet. The bed had not been opened, and none of its characteristics were known. Above the coal was found the outcrop of a ferruginous, argillaceous shale.

On the hill directly east of the barn on C. Stubb's place, a second outcrop was found, where a little digging had been done in the bed, at an elevation of 1950 feet. The bed here was reported to be from 2 to 3 feet thick, with both a fire-clay roof and floor. This bed was supposed to be the *Alton Lower*, and the outcrop found to the east was taken to mark the horizon of the *Marshburg Upper bed.*

The elevation of the cross-roads, near the line separating warrants 3776 and 3780, is 2005 feet. The rock immediately underlying the surface at this point was taken to be the JOHNSON RUN SANDSTONE. I believe the ground is not sufficiently high to take in the *Clarion coal bed.* It is not known that any explorations have been made for this coal bed, but, if it should be found, but small areas would be underlaid by it, and those only on the highest summits.

The road from the cross-roads leading toward Kane is very nearly level. The greatest elevation, which was measured at any point, was about midway between the cross-roads and the point where the road crosses the township line separating Jones from Highland. This elevation is about 2010 feet. From observations made on either side of this road, no indications were found, which would lead to the conclusion that any rocks higher than the JOHNSON RUN SANDSTONE might underlie even the highest summits.

The Tionesta creek, which flows through the northern portion of the township, has cut the bottom of its valley out of the POCONO SANDSTONE.

No indications were seen here of any red shale. The MAUCH CHUNK FORMATION No. XI seems to be represented in this section entirely by gray shales. Although on the geological map of the county (Plate II) the outcrop of No. XI is indicated by a red line, this color has been used, as in many other places in the district, merely as a conventional to show the position of this formation, and not as an indication that the rocks which it stands for are actually of a red color.

In warrant 3778, the highest summit, near its center, would appear to be capped by the lower part of the JOHNSON RUN SANDSTONE. Although no outcrops were found of the coal

beds which underlie this rock, particularly those of the *Alton group*, it is safe to conclude that, if their outcrops should ever be located, no coal beds would be found of sufficient thickness or purity to warrant the hope that a profitable mining operation could ever be undertaken. As has been stated in many parts of this report, the general characteristics of these beds, that of being very sporadic in thickness and containing very slaty coal, would rather support the view here expressed.

The developments of the *Alton beds* which have been made on the Keystone tract east of St. Mary's (see page 167), and on the Connor lands north-west of Centerville (see page 186), are fair instances of the experience of those who have made an effort to mine coal from these beds at a profit. This same conclusion would apply with equal force to the areas along the northern line of Highland, and those elsewhere in the township, which are capped by the JOHNSON RUN SANDSTONE, where it might be reasonably expected that these coals might be found.

Hopes have been entertained by many of the land owners and oil prospectors who have leased land in the township, that a profitable pool of petroleum might be found underlying its area. The developments, which have so far been made, go to show that there is, without doubt, petroleum in some of the DEVONIAN SANDS underlying its area at considerable depths, but that these sands will be found to contain oil, in sufficient quantities to make it a profitable investment to drill wells for its development, has yet to be proved. More special reference is made to the probable existence of oil here in Part I of this report.

Chapter XV.

Spring Creek Township.

Spring Creek lies east of Millstone, south of Highland, west of Ridgway and Horton, and north of Snyder, Polk, and Heath townships in Jefferson county.

The drainage of the township is effected by the Clarion River and its branches, which has a sinuous course through its central part, although it leaves the township almost due west of the point where it enters it, its greatest deflection north of this line being about two miles, near the mouth of Spring creek.

The principal streams which flow into the Clarion, from the north, are Bear creek, Crow run, Laurel (Irwin) run, and Spring creek, and from the south, Little Toby creek and Samuel Baird Maxwell run.

A singular feature which may be observed in the course of Laurel run and of one of the head branches of Spring creek in Highland township, is the fact that both flow in a general way, south, along the same north and south line. If the suggestion which I have made, that the rocks may be jointed north and south in western Elk county, be of any value, it might appear that the course of these two streams may have been determined by the same cause. The explanation which I have suggested, of the north and south parallel flow of a number of the streams in western Elk county, will need the collection of many more facts to confirm it, before it can be accepted as the true explanation.

The topography of the township is not unlike that of Ridgway, except that the plateau summits may be more extensive and more marked. The largest of these summits, in Spring Creek, is that south of Irving's Mills, in the vicinity of the cross-roads, called Lake City.

The highest elevation in the county is probably along its

northern line, between Bear creek and the headwaters of Spring creek; this, however, was not determined with any accuracy by the Survey. The lowest point is where the Clarion leaves its south-western corner, at an elevation of about 1250 feet.

Spring Creek lies almost exclusively within the *Johnson Run or Fifth Bituminous basin.* The *Fourth anticlinal axis* cuts across its extreme south-eastern corner, and the *Fifth anticlinal axis* crosses its extreme north-western corner. Very little coal is contained within the boundaries of the township, from the fact that the surface is eroded very much lower than that of northern Ridgway or Jones, and that the axis of the basin does not seem to sink toward the south-west, from the *Silver Creek basin.* The result is, that, as far as it could be ascertained from the limited amount of prospecting work which has been done in search of coal beds, the strata capping the highest summits are, with but one or two exceptions, those immediately overlying the *Clarion coal bed.*

On the geological map of the county (Plate II), two small areas have been outlined as being underlaid by the *Ferriferous limestone.* Although no limestone was actually found at either of these places, the ridges would seem to be high enough to include it.

Another section north of Irwin's Mills appears to contain a limited area of the *Lower Kittanning coal bed.*

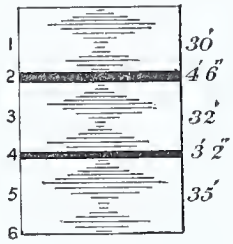
The most important developments of the coal beds which have been made has been in the vicinity of Irwin's Mills and of Spring creek. The former area was examined in August, 1878, by Mr. A. W. Sheafer, accompanied by Mr. Thomas Irwin, and the latter was examined and mapped by Prof. Lesley in 1865, and subsequently by myself.

In the vicinity of Irwin's Mills the following section was measured by Mr. Sheafer (Fig. 84, page 278):

Summit, 1785′

1. Interval, concealed; upper part probably composed of shale and slate, 20′; over top a stratum of fine-grained yellow sandstone, ... 75′
2. Fine-grained white and yellow sandstone, (JOHNSON RUN SANDSTONE,) . . . . . 45′

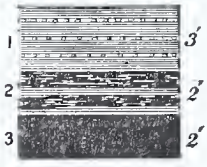
Fig. 87. p. 294.
Bingham Lands.



100'=1"

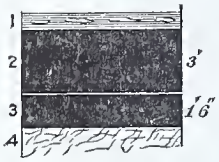
Sections in the vicinity of Irwins Mills.

Fig. 86. p. 294.
Lower Alton Bed Irwin tract.



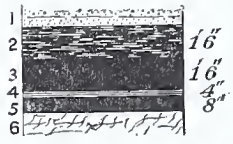
10'=1"

Fig. 89. p. 295.
Clarion (?) Bed, Laurel Run.



10'=1"

Fig. 85. p. 293.
Upper Alton Bed, Irwin tract.



10'=1"

Fig. 88. p. 295.
"Clay" Bed Laurel Run.

10'=1"

3.	*Alton Upper bed*,	4′ 5″
4.	Interval,	10′
5.	*Coal outcrop*, (*Alton Middle bed*,)	2′
6.	Interval, (slate and fire-clay (?),)	16′
7.	*Alton Lower coal bed*,	3′ 2″
8.	Interval; sandstone at 1565′; soft-grained slate at 1470′,	265′
9.	Fine-grained flaggy sandstone,	25′
10.	Interval,	15′
11.	Fine-grained gray and yellow sandstone and flat pebble conglomerate, (SUB-OLEAN CONGLOMERATE,)	30′
12.	Interval,	30′
	Clarion River at Irwin's Mills, 1265′	
	Total,	520′ 7″

Comparing this section with others in the county, it would appear that the horizon of the *Lower Kittanning coal bed* is marked, very nearly, by the summit. Although, as far as known, no prospecting for this coal bed has been done, at this point; it might be possible to find a small area of it immediately capping the ridge.

A considerable area exists here, underlaid by the geological plane marking the position of the *Clarion coal bed*, but the coal bed has never been found.

Nothing can be predicted as to the character of the *Clarion coal bed*, if it should be found in this locality. From the fact, however, that the hills are high enough to contain it, a search for it would certainly be warranted.

The JOHNSON RUN SANDSTONE forms a marked feature in the profile of the hills. The interval between, what appears to be, its top and the top of the *Alton Upper coal bed* is 45 feet. How much of this is filled by the sandstone, it would be impossible to determine.

The *Alton Upper coal bed* was opened by Mr. Irwin in the early winter of 1877. The drift, when visited, had been driven in 80 feet; the coal dipped to the south-west. The section of the bed was as follows (Fig. 85, page 292):

1.	Sandstone, (roof,)	—
2.	*Bony coal*,	1′ 6″
3.	*Coal*,	1′ 6″
4.	Slate,	4″
5.	*Coal*,	8″
6.	Hard sandy fire-clay, (floor,)	—
	Total,	4′

The floor of the coal bed is locally considered to be a sandstone, and, as far as developed, it is reported that no clay was found underneath the coal. The stratum is, however, probably a very siliceous fire-clay. It contains numerous black specks, which appear to be fragments of Stigmaria.

A drift was started by Mr. Irwin on the *Alton Middle bed*, which measured 2 feet in thickness near the outcrop. The coal was very clayey, and the drift was abandoned.

The *Alton Lower coal bed* was opened by a drift, driven in 1852–3, which had fallen shut when visited by Mr. A. W. Sheafer. This opening was visited by Mr. P. W. Sheafer, in 1857, and the following section was reported (Fig. 86, page 292):

1. Slate, with occasional nodules of iron ore,	3′
2. Black slate and *bony coal*,	2′
3. *Coal*, tolerably good,	2′
Total,	7′

The *Alton coal beds* have very much the same character here as observed elsewhere in the district. The coal is generally of inferior character and cannot be mined or sold at a profit in an open market, where it is brought into competition with better and purer coals. What has so far been mined, in this locality, is understood to have been locally consumed.

Mr. A. W. Sheafer constructed the following section on the Bingham lands, in warrant 1569, north of Irwin's Mills and north of Laurel run (Fig. 87, page 292):

Summit, 1790′	
1. Interval,	30′
2. *Coal bed*,	4′ 6″
3. Interval,	32′
4. *Coal, Clay bed*,	3′ 2″
5. Interval,	35′
6. *Coal*,	—
Total,	104′ 8″

The *Clay bed* was opened by Mr. Irwin in 1871 on one of the head forks of Laurel run. Coal was taken out of the bed as long as the dip would allow. A drift was opened in the bed in a northern direction up the dip of the bed for a

distance of 60 feet, when a chamber was opened 20 by 7 feet. The section of the bed, near the face of the mine, was as follows (Fig. 88, page 292):

1. Slate, (roof,)	—
2. *Coal*,	8″
3. Fire-clay,	10″
4. *Coal*,	1′ 8″
5. Fire-clay, (floor,)	—
Total,	3′ 2″

The coal contains considerable pyrites. A sample of it was analyzed by Mr. Curtis, of Erie, and found to contain considerable gas. The bed is locally called "*the Clay vein*," on account of containing a bed of clay separating the two coal benches. It is said by Mr. Irwin to be the same bed as that opened at the *Messenger mine*, at the mouth of Spring creek. Sufficient facts are not at hand to determine its true identity; it is probably, however, the representative of the *Alton Upper bed*. The coal taken from the drift was used for mill and family use for five years succeeding its opening, at the rate of from 300 to 500 bushels per year.

A few hundred feet up the hill from this coal opening a shaft was dug near the bed of the stream, but, on account of filling rapidly with water, it was abandoned. It was reported that near the bottom of the shaft 1 foot 2 inches of coal and slate were found.

Thirty five feet above the *Clay bed* another bed was opened on the left bank of the stream, a section of which measured as follows (Fig. 89, page 292):

1. Black slate containing slabs of carbonate of iron ore, (roof,)	—
2. *Coal*,	3′
3. *Coal*,	1′ 6″
4. Fire-clay, (floor,)	—
Total,	4′ 6″

Mr. Irwin reports that the lower bench of the bed contained a harder, drier and better coal than the upper. The drift where this bed was opened had fallen shut when visited. Mr. Curtis also tested the coal obtained from this

bed and reported it well adapted for manufacturing purposes. This bed may be the representative of the *Clarion coal.*

Mr. Irwin reported that an engineer of the Warren and Dunkirk R. R. visited these openings just before the panic of 1873. It was proposed, at that time, to run a narrow gauge railroad from Sheffield to this opening, a distance of 18 miles, which would permit the mining and shipping of coal from these coal beds.

As far as known, no extensive search for any coal bed has been made south of the Clarion River in southern Spring Creek. This area is so barren of natural outcrops that nothing can be decided as to the existence of coal here, except by actual prospect work. It would appear, however, judging from the topographical features, that the ridges are sufficiently high to contain a considerable area of the *Alton coal beds*, with possibly a limited area underlaid by the *Clarion bed.*

On the sheet of sections accompanying this report (Atlas RR, Plate VI) is given a section of the coal measures found in the hills immediately surrounding Spring Creek. Reference is made, in Part I of this report, to the section of the Spring Creek well and its comparison with other well sections on the same sheet.

Chapter XVI.

Millstone Township.

Millstone lies east of Barnett and south of Jenks townships in Forest county, west of Spring Creek, and north of Heath in Jefferson county.

The western and greater portion of the township is drained by Millstone creek and its branches, and the eastern portion by Wilson run. Both of these streams flow into the Clarion River.

The topography is characterized by the same features as that of Spring Creek township, particularly of the southern portion of the latter township south of the Clarion River. The similarity to this section is more marked, on account of the fewer streams and the broad flat areas between them.

The character of the summits results from the fact that they are immediately underlaid by one of the sandstone or conglomerate members of the Pottsville No. XII. Generally, where the surface is immediately underlaid by the softer coal measures overlying the conglomerate, the topography is more irregular, the summits not being as flat, but more broken, and the profiles of the hills more irregular. This is due to the varying hardness of the strata of the lower coal measures, and the differences in their susceptibility to natural erosion. Softer strata, when overlaid by harder strata, form a steeper slope than that formed by the harder strata, except along the edge of a bluff, when the harder strata may be left in sharp escarpments by the undermining and erosion of the softer strata. This was observed at several places in the township, where the softer rocks under the sandstones of No. XII have been cut away, and the sandstones have been eroded by the breaking off of portions of them in huge blocks, which have been strewn along the hill-

slopes or the valleys, rather than by a piece-meal destruction, as in the softer measures.

Millstone has done its share to supply the lumber trade which has been so extensively carried on in the Clarion Valley, and the result has been, that a great portion of its surface is stripped of its forests.

The cold barren soils, resulting from the disintegration of the rocks immediately underlying the surface of the township, have, in a very few places, supported a second growth of timber, so that the surface in many places is rough, and void of any growth, which is of present value. To this extent it is in bold contrast to the surface of Highland township.

The greatest elevation in the township is near the northern north-western corner. The lowest point is, of course, where the Clarion River crosses its western line into Forest and Jefferson, at an elevation of about 1200 feet.

Almost the entire surface of Millstone township, with the exception of the extreme south-eastern portion, lies west of the *Fifth anticlinal axis*. There is little of interest to the geologist to be found in this township, as so few rocks have been exposed *in situ* within its limits. The highest portions of its surface, as far as it has been possible to determine, are capped by one of the members of the POTTSVILLE CONGLOMERATE No. XII.

In the north-western warrants, the outcrops of one or two coal beds have been proven, by openings. All of the known coal openings have, however, fallen shut, so that it was impossible to see a section of the bed. Hopes have been entertained by a number of people that coal beds, which it would be profitable to mine, would some time be found in this township; all the indications go to show, however, that the only coal beds which exist here are those of the *Alton group* and the *Marshburg Upper* and *Lower coals*. Judging from the character of these beds where they have been developed in Elk county, and in Jenks township, Forest county, more particularly in the vicinity of Marienville, little hope can be entertained that any of these beds, if they exist at all, underlying any considerable area, will be of

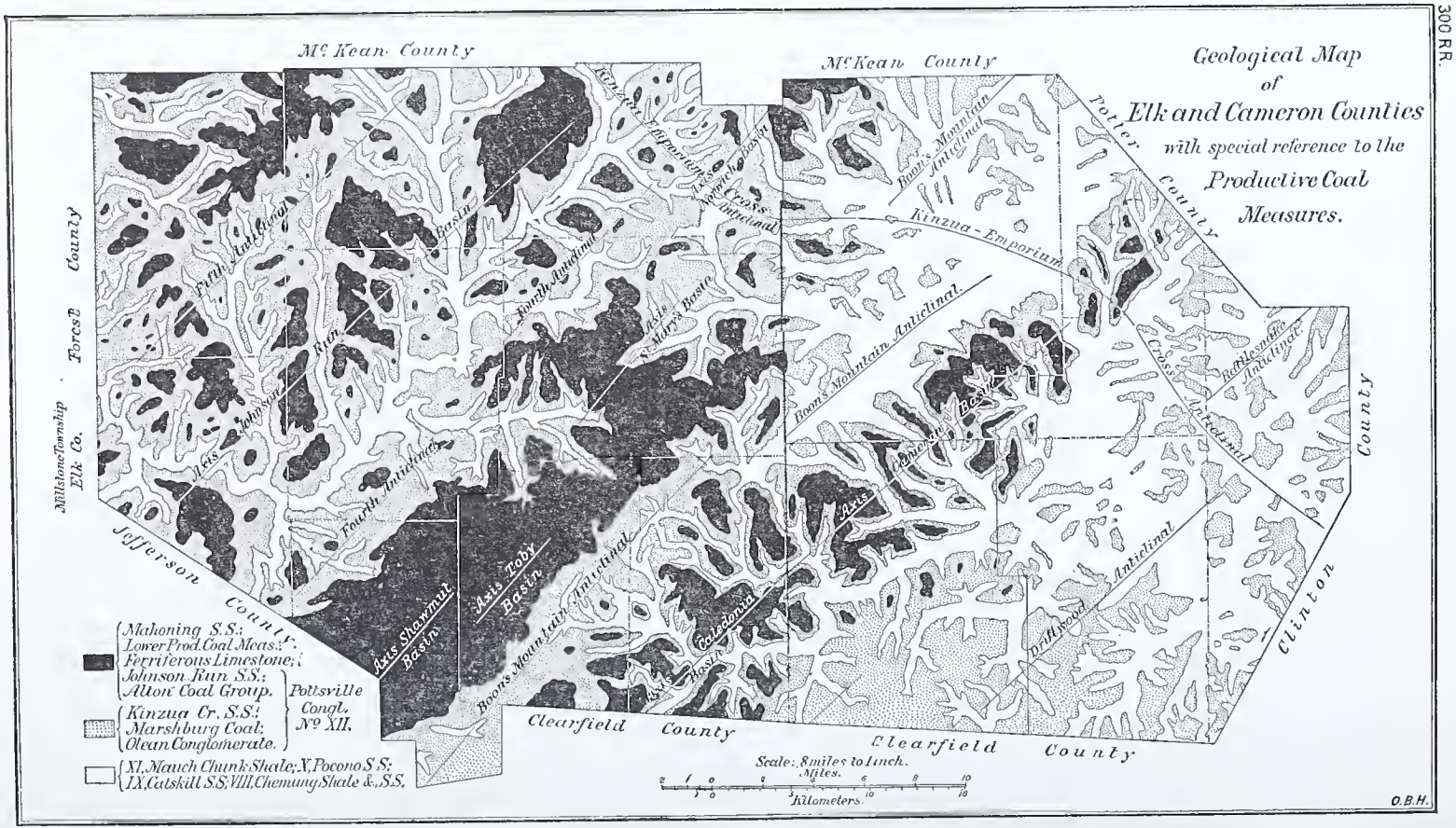
sufficient thickness, or contain coal of sufficient purity, to enable them to be profitably mined.

It has been thought by many oil men that a paying oil pool might be developed. From the provings, which have so far been made by drilling, no facts have been obtained which would support such a view, and I have been rather impressed with the idea, that those who have entertained the most sanguine expectations that petroleum would be found here, have based their conclusions upon a theory, which has had no little influence upon many oil men, and that is, that an area which was good for nothing else, and which was either encircled by profitable wells or lying adjacent to a paying district, might contain petroleum.

Those who are most familiar with the area embraced within the boundaries of this township, I think, make no claim as to the value of the land either for agricultural or coal mining purposes, so that, if there was any reason in such an argument, petroleum might be found. It must occur, however, to any reasonable person, that such facts can have absolutely no influence upon the question whether petroleum does or does not exist underlying such an area. Reference has already been made to this in the description of the general geology in Part I of this report.

Cameron and Elk Geological Map.

On page 300 is a map of Cameron and Elk counties (scale 8 miles to 1 inch) reduced from the county geological maps, (Plates II and III atlas RR,) which shows those areas, in the two counties respectively, which are underlaid by the Olean conglomerate and Kinzua Creek sandstone and by the coal measures above the top of the Kinzua Creek sandstone. Those areas which are underlaid only by the Mahoning sandstone, at the top of the Lower Productive coal measures, are very limited; they have never been definitely located, and are, therefore, not represented on the map. A general idea as to their extent can be formed from the detailed descriptions of the township geology already given.


Geological Map
of
Elk and Cameron Counties
with special reference to the
Productive Coal
Measures.
McKean County
McKean County
Potter County
Forest County
Millstone Township
Elk Co.
Jefferson County
Clearfield County
Clearfield County
Clinton County
Kinzua - Emporium
Boon's Mountain Anticlinal
Boon's Mountain Anticlinal
Fifth Anticlinal
Fourth Anticlinal
Fourth Anticlinal
Axis Johnson Run
Axis St. Mary's Basin
Axis Norwich Basin
Axis Cross Anticlinal
Axis Cameron Basin
Axis Toby Basin
Axis Shawmut Basin
Axis Caledonia Basin
Drillwood Anticlinal
Cross Anticlinal
Battlesnake Anticlinal
Mahoning S.S.; Lower Prod. Coal Meas.; Ferriferous Limestone; Johnson Run S.S.; Alton Coal Group.
Kinzua Cr. S.S.; Marshburg Coal; Olean Conglomerate.
Pottsville Congl. No XII.
XI, Mauch Chunk Shale; X, Pocono S.S.; IX, Catskill S.S.; VIII, Chemung Shale &, S.S.
Scale: 8 miles to 1 inch.
Miles.
Kilometers.
O.B.H.

REPORT OF THE PROGRESS

OF THE

SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA

IN

FOREST COUNTY,

By Charles A. Ashburner.

GEOLOGY OF THE COAL MEASURES.*

Chapter XVII.

Introduction.

The study of the geological structure of Forest is probably fraught with greater difficulties than that of any other county in Pennsylvania, west of the Allegheny mountains.

The county lies in a region where the rocks are nearly horizontal, the average dip, per mile, being less than the average grade, per mile, of most of the railroads, in the north-western part of the State.

*In Part I, of this report (RR). will be f und numerous records of oil wells and dry holes drilled in Cameron, Elk, and Forest counties, with a general description of the structural and stratigraphical geology of the district, with special reference to the "oil rocks." Sections of some of these records have been published on Plates V and VI, contained in the accompanying atlas (RR). Since these plates were printed in 1879, additional facts have been obtained, which slightly modify the connection of the strata, which is indicated between the sections on Plate VI. Reference is made to this in Part I.

The region is almost a continuous and dense forest; comparatively little lumbering had been done, within the confines of the county, except in the region immediately adjoining the Allegheny River, the Tionesta creek and the Clarion River, prior to the summer of 1879, when the survey of the county was made conjointly by Mr. A. W. Sheafer and myself.

Generally but few rock exposures, except of the coal measure conglomerate, are found throughout the district, and even these are so broken up, where found, that it is difficult sometimes to determine the exact position which the formations occupy when *in situ*.

The thickening and thinning of the rocks have now been absolutely proven by the numerous oil wells which have been drilled.

All of these facts have introduced difficulties into the work, which has made the geological exploration of the coal measures in the county very unsatisfactory.

Oil Rocks.

The survey of the oil regions has been prosecuted especially under the direction of Mr. John F. Carll, and what work has been accomplished by other geologists, connected with the Survey, has only been done in carrying on their studies of the general geology of the counties in which oil has been found, and in mapping, more particularly, the strata which outcrop above water level.

When I was first sent into this region, my commission, from the State Geologist, required a survey of the surface geology of the coal measures of McKean county. Afterwards, I was instructed to make an examination and survey of the rocks outcropping above water level, more particularly those of the coal measures, in the counties of Forest, Elk, and Cameron; so that, I was not called upon to make any examination of the oil rocks lying below water level, or a survey, either of the developed oil districts, or those which might in the future be found to contain petroleum.

In the prosecution of my examinations, in compliance with the instructions of the State Geologist, many facts

were obtained, bearing upon the stratification of the rocks, down to and including the oil sands, but no special effort was made to collect facts bearing upon the oil geology, which I was not expected to report upon.

The limited appropriations of the Survey did not permit Mr. Carll to survey all the oil districts as he had hoped to do. In the case of the Bradford oil field, there was published in Report R on McKean county, a general description of its geology, which was not sufficiently thorough and of as great practical utility, as a report which should be based upon facts collected in a special survey of the oil fields. The exhaustion of the State appropriation after the publication of Mr. Carll's report on Warren county did not permit him to extend his investigations into Forest county and report upon its oil geology.

The facts which are presented in Part I of this report and on the sheets (Plates Nos. V and VI) of oil well sections in the atlas, bearing upon this subject, are merely those which have come into my hands in a more general examination of the surface geology of the county, and a survey, more particularly, of its coal measures.

Coal Measures.

The coal measures of Forest county, although different, in many of their minute characteristics, from those found in the counties adjoining Forest, yet, in a general way, bear a close resemblance to those in Elk and McKean counties.

Numerous openings have been made in the coal beds in different parts of this area, especially in Jenks township, in the vicinity of Marienville. Although all the openings have been made, either to test the value of special tracts for extensive coal mining or for the procurement of coal for blacksmiths' purposes, no effort has been made to mine coal, either for general local consumption, or for shipment to near or distant markets. The abundance of wood has always furnished an ample fuel for local consumption, and, until within the last two years, no railroad existed for the shipment of coal, if it had been mined.

The recent finding of natural gas, and its general use

both for fuel and light, has now almost entirely diverted the attention of the property owners and the general public from further explorations for workable coal beds.

The value which has been attached to most of the Forest county lands, as actual or prospective oil territory, exceeds so greatly their possible value for coal mining, under the most favorable conditions, that many of the more recent residents in the county and owners of its lands are not even aware of the fact, that any coal beds occur under its surface, or that there is the most remote possibility of coal beds ever being found.

Although, as is pointed out in the following pages, little hope can be entertained, that any coal beds will ever be found within the county limits which will be thick enough, or contain coal good enough, to be profitably mined, yet a careful study of the geological structure of the rocks, particularly those of the coal measures, occurring in the county above water level, will no doubt throw much light upon the structure (particularly the dip) of the underlying strata, *in which oil may be found*, which will be of the greatest practical utility to the oil prospector and producer.

A number of capable and experienced geologists have made examinations of the coal beds of the county; the openings, however, have been so scattered, and the rock exposures so few, that it has been practically impossible for them to determine the relationship of the coal beds in the different openings, which have been made, without a more extended examination than appears to have been made by any of those geologists who have published the results of their work.

Within recent years the drilling of the Hunt wells in the vicinity of Marienville, and the careful and systematic tracing of the strata by the assistants of the Geological Survey, from the surrounding counties toward and into Forest, have thrown much light upon the geology of the coal measures, which seems to permit at the present time of the determination of what coal beds, found in other and well developed coal areas, are represented in Forest county.

The most perplexing fact, and one which has introduced

into the study of the coal measures a confusing difficulty, has been that most of the high summits in the county were immediately underlaid by a sandstone or conglomerate.

The geologists of the First Survey, and those who followed them in private examinations, noted the fact that there was more than one sandstone and conglomerate bed in the county. Although no satisfactory differentiation had ever been made of these two or three distinct sandstone and conglomerate beds, which seemed to be generally admitted as having an existence, the solution of the problem was attempted, and the most prominent sandstone, found in the Tionesta valley, was given the name of the TIONESTA SANDSTONE, (See page 72).

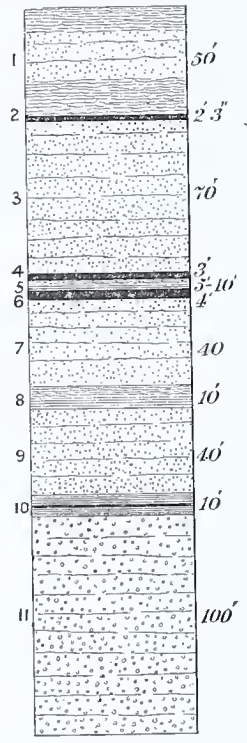
In the light of the facts which the oil wells have developed, it would appear now that the name TIONESTA was never strictly confined to the same sandstone or conglomerate bed, but was applied indifferently to one of the three distinct members of the CARBONIFEROUS or POTTSVILLE CONGLOMERATE No. XII (JOHNSON RUN SANDSTONE, KINZUA CREEK SANDSTONE, and OLEAN CONGLOMERATE) now found to exist.

The infrequency of the exposures, not only of the softer measures, but also of these hard massive sandstones, would probably have prevented a satisfactory solution of the problem, had it not been for the facts which have been recently procured, through the few records of the oil wells which it has been possible for the Survey to obtain.

During the years 1878 and 1879, when the examination of the coal measures in this county was made by my assistant, Mr. A. W. Sheafer, and myself, the county was so thinly settled, and the few inhabitants, who were seen, knew so little about the search which had been made for coal beds, that miles were traveled, at times, without finding a single exposure, and several days would frequently pass without our obtaining any information, except such as could not be confirmed or which was absolutely misleading. The Survey owes much to Col. J. D. Hunt, and Dr. S. S. Towler, of Marienville, who are personally familiar with the work which had been done in prospecting for coal; they not only fur-

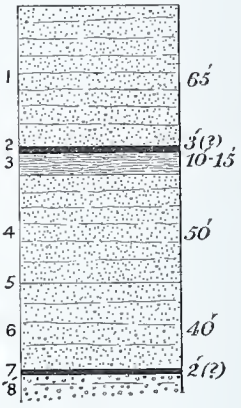
Sections of Coal Measures in Forest County.

Fig. 90 p. 307.
General Section Jenks Township.



100′=1″

Fig. 91. p. 309.
Vicinity of Marienville.



100′=1″

Fig. 92. p. 311.
Upper Marshburg Bed 80 acre lot.

Fig. 93. p. 317.
Upper Marshburg Bed Funk tract.

Fig. 94. p. 318.
Upper Marshburg Bed Warrant 2991.

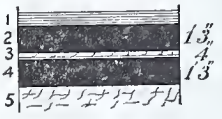
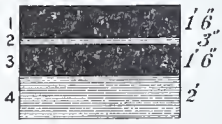


Fig. 95. p. 320.
Heath Bed Heath Farm.

Fig. 96. p. 321.
Hazlitt Bed Bond Lot.



10′=1″

furnished the Survey with all the facts in their possession, but were untiring in devoting their personal assistance in acting as guides to Mr. Sheafer and myself, in visiting localities in the county, where it was thought any facts might be obtained from field observations.

Jenks Township.

The general compiled section of the coal measures found in the county, and more particularly in Jenks township, is as follows (Fig. 90, page 306):

1.	Shales and sandstones,	50′
2.	*Clarion coal bed*,	2′ 3″
3.	JOHNSON RUN SANDSTONE,	70′
4.	*Alton Upper coal bed*,	3′
5.	Shales and slates,	5′ to 10′
6.	*Alton Lower coal bed*,	4′
7.	KINZUA CREEK SANDSTONE, UPPER MEMBER,	40′
8.	Shales and slate,	10′
9.	KINZUA CREEK SANDSTONE, LOWER MEMBER,	40′
10.	*Marshburg slates*, containing a *coal bed* 2 feet thick,	10′
11.	OLEAN CONGLOMERATE,	100′
	Total,	334′ 3″+

The ridge which runs in a north-eastern direction, from Tylersburg in Clearfield county, at an elevation of 1627 feet, to Howard Hill in McKean county, is generally known as the "*Big Level ridge.*" The summit of this ridge is a gradually ascending one from its south-western to its north-eastern end. At Tylersburg the elevation is 1627, at Marienville 1728, near Sheffield Junction 1885, at Spring Creek 1950±, at Kane 2020, and at Howard Hill 2249 feet. Along the crest of the ridge, from Tylersburg to Howard Hill, (40 miles, in an air-line,) there is scarcely a break, where its summit has been eroded more than 15 or 25 feet below the line of this ascending plane.

In Forest county the summit of this ridge is generally capped by the JOHNSON RUN SANDSTONE, and, at a few points, by the shales above this sandstone, which compose the interval between the *Clarion coal bed* and the *Ferriferous limestone.* Nowhere, however, is the surface of the county believed to be high enough to contain the geological plane marking the horizon of the *Ferriferous limestone.*

In the south-eastern part of warrant 3173, and about a mile and a half east of Marienville, a coal bed has been opened, at what is known as the *Pine Ridge opening*. This coal has been taken to be the representative of the *Clarion bed*. The elevation of the bottom of the bed at this opening is 1742 feet.

The summit immediately above the opening is 50 feet higher than the coal bed at the opening. At no place in McKean or Elk county was the thickness of the shales and sandstones between the *Clarion bed* and the *Ferriferous limestone* found to be as much as 50 feet, so that, from a direct comparison, it would appear that this hill *might be* high enough to contain the *Ferriferous limestone*. That it does not contain a stratum which may represent the limestone, (may not be a pure limestone) cannot be positively asserted, because it has been found that in southern Jones and northern Ridgway townships, Elk county, this limestone has deteriorated into a siliceous chert, which probably contains very little or no calcareous matter, since specimens of it showed no effervescence with hydrochloric acid.

From a general comparison of the section of the coal measures in Forest county with those to the east and north-east, it is found that the sandstone members of the POTTSVILLE No. XII augment very much in thickness in a western and south-western direction, towards Forest county; also, that the upper portion of the JOHNSON RUN SANDSTONE, and the strata composing the interval above it, become more massive, and have more of the characteristics of a sandstone, than usual; it is more than probable that the rocks between the *Clarion coal bed* and the *Ferriferous limestone* augment also in thickness from McKean and Elk counties into Forest.

On the sheet of oil well sections (Plate VI), from Cameron county to Venango county, is shown the estimated position of the *Ferriferous limestone* above the top of the oil wells, the sections of which are given.

The elevation of the summit half a mile east of Col. Hunt's house, not far from the Marienville cross-roads, is 1805 feet. The summit is capped by a rather coarse-grained ferru-

ginous sandstone. A white cement unites the grains of sand, which are rounded and compact. No pebbles were seen in this rock, which, as far as could be determined, is the top of the JOHNSON RUN SANDSTONE.

The section of the coal measures at Marienville, below this summit, is as follows (Fig. 91, page 306):

1. JOHNSON RUN SANDSTONE,	65′
2. *Alton Upper coal bed*,	3′(?)
3. Alton shales,	10′ to 15′
4. KINZUA CREEK SANDSTONE, UPPER MEMBER,	50′
5. Spring; probably marks softer measures and *coal horizon*,	—
6. KINZUA CREEK SANDSTONE, LOWER MEMBER,	40′
7. *Marshburg Upper coal bed*,	2′(?)
8. OLEAN CONGLOMERATE,	—
Total,	170′+

The upper coal bed of this section is reported to have been struck, at a depth of 14 feet, in a well at Thomas Walton's house, to the right of the road, in going from Eldridge's to Col. Hunt's, the elevation of the bottom of the coal being 1760 feet. This same bed was opened on the Beaver Dam tract, about three miles and a quarter, in an air line, a little east of north from Marienville, the elevation of the bed at this point being 1745 feet.(?) This bed was opened about 15 years ago, and coal was dug at this point for two years for blacksmiths' use. The coal was slaty and cannelly, and produced a poor fuel.

Two feet above this bed another coal was opened, the thickness of which was not reported. At Eldridge's, what appeared to be the same bed, was opened, at an elevation of 1730 feet; where the bed was opened on the outcrop, it measured 2 feet 6 inches thick, but contained a great deal of slate, the benches of coal between successive layers of slate being very thin. The coal was iridescent and had a fatty appearance, probably being high in volatile hydrocarbons. The bed, however, produced an almost worthless fuel.

No coal bed has been opened, in the vicinity of Marienville, as far as known, which would probably represent the *Alton Lower bed;* the shales which are exposed immediately below the cross-roads are probably, however, the representatives of those found in the *Alton group.*

The *Upper Marshburg bed* has been opened near Colonel Hunt's old house* and 40 feet below it, at an elevation of 1660 feet. The coal was of a splinty nature, and contained considerable slate and iron pyrites. The thickness of the bed near the outcrop was 1 foot 6 inches.

Between these two coal beds, and generally about 40 feet above the lower, and about 10 feet vertically below Colonel Hunt's house, there is a line of springs, which probably marks the softer strata between the two members of the KINZUA CREEK SANDSTONE. Immediately south-west of the Marienville cross-roads, a coal bed is said to outcrop at about the same elevation as these springs.

In the road north of the old school-house, at the old Parker farm, at an elevation of 1690 feet, a great deal of iron is contained in the soil, and the indications are, that, if diligent search should be made, a *bog iron ore* deposit might be found, but certainly not of sufficient purity to prove a workable bed.

No coal has been prospected for at this horizon. There is every indication, however, that at this point, in the section, the strata are more argillaceous, slaty, and shaly than above or below it.

The dual character of the KINZUA CREEK SANDSTONE, which seems to be very marked, where any section of it can be obtained, is quite characteristic in Forest county. Although there are indications that the KINZUA CREEK formation in Elk and McKean counties at places contains softer and more thinly-bedded strata near its center, no sections of it have been obtained in those counties which might warrant the conclusion that such is its general structure.

This structure of the KINZUA CREEK ROCK appears favorably in sections made to the west of Forest, where the CONNOQUENESSING SANDSTONE, which is taken to represent the KINZUA CREEK SANDSTONE, is composed of two members.

I have been informed that, in some localities, a streak of coal has been found from 15 to 30 feet below the *Alton Upper (?) bed.*

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*Col. Hunt's new house was not erected until 1883.

The elevation of Salmon creek at the bridge west of Hunt's is 1492 feet. About a quarter of a mile from Hunt's old saw-mill, near the bridge, a shaft was dug and a coal bed found, which was very slaty and was 1 foot 6 inches thick. No slate roof was found above the bed, so that this may not be its correct thickness.

A short distance from this opening, about 50 rods north of Towler and Hunt's well No. 4, near the Salmon creek bridge, a coal bed outcrops, the elevation of the bottom of the bed being 1617 feet, as determined by Mr. A. B. Howland. This is the *Upper Marshburg bed*, and the elevations would indicate a dip in the strata from Hunt's north-west to this point.

The elevation of the top of the ridge, above this coal bed, is about 1670 feet, and it is capped by the KINZUA CREEK ROCK, which consists here of a loose-grained, yellowish sandstone.

A lower summit, above the coal bed, (elevation 1640 feet) is capped by the OLEAN CONGLOMERATE, which is a coarse-grained gray sandstone containing a few small pebbles, alternating with conglomerate layers containing pebbles the size of a hickory nut. Huge blocks of the OLEAN are found here, one of which is nearly square and measures 50 feet on the side and 25 feet high. Parts of the rock are very ferruginous, and their surfaces, when exposed to the weather, are crossed by ridges, in which the iron ore seems to have segregated. The lower portions of the OLEAN are more conglomeritic.

On what is known as the 80-acre lot, near Marienville, at an elevation of 1610 feet, an opening has been made in the *Upper Marshburg bed*, the section of which is as follows (Fig. 92, page 306):

1. *Bituminous coal*,	3″
2. Black slate,	1′ 3″
3. *Coal* and slate,	3′±
Total,	4′ 6″±

The face of the coal was opened for a distance of 50 feet in a drift running east and west. The upper bench of coal thins rapidly and entirely disappears. Dr. Towler reports

that the lower bench produces a great quantity of ash and cinder when being burned. The thinner upper bench seems to contain a highly volatile coal. The dip of the bed is to the north-west. The bed is overlaid by a gray micaceous, sandy slate, containing fragments of stigmaria. This is overlaid by a coarse-grained gray and yellow sandstone, which is the character of the rocks at the cross-roads at Marienville. This bed was opened in 1873 by Dr. Towler.

Most of the bottoms of the valleys in the vicinity of Marienville contain deposits of *bog iron ore*, the iron which is contained being washed out of the sandstone and conglomerate measures of the POTTSVILLE No. XII. These ores have been dug into, to a limited extent, with the hope of finding a deposit rich enough for working. The search has, however, met with failure, and there are no indications, which would warrant the hope being entertained, that a deposit rich enough for iron manufacturing will ever be found.

In a dry hollow below the Marienville cross-roads a cannelly bed was opened, which measured 2 feet thick, which is the representative of the *Marshburg Upper bed.*

In the eastern part of warrant 3173 a coal bed has been opened at what is know as the *Pine Ridge opening*, the elevation of the bottom of the bed being 1742 feet. A section of this bed was not obtained. This coal was taken to be the representative of the *Clarion bed*, which occurs immediately above the JOHNSON RUN SANDSTONE. There is 20 feet of cover immediately over the coal opening. The elevation of the top of the ridge to the east is 1790 feet. It is believed that the *Clarion bed* has been eroded from the summit in the vicinity of Marienville, which is 1905 feet high, so that the sandstone, which at the Pine Ridge opening lies entirely below the coal bed, at an elevation of 1742 feet, must dip considerably toward the east. This conclusion, taken in conjunction with that as to the dip of the coal bed north of Marienville, would indicate that an anticlinal passes north-east and south-west through Marienville.

Descending from the Pine Ridge opening towards Millstone creek, there is a marked terrace, at an elevation of 1680 feet, which is probably produced by the softer shales and

slates of the *Alton group*, the steep declivity above the terrace being formed by the JOHNSON RUN SANDSTONE.

In the bottom of Millstone creek, at an elevation of 1593 feet, a coal bed has been opened which measured 4 feet thick, including the coal and alternating slates. In the center of the bed there is one solid good bench of coal 2 feet thick. This opening was made a number of years ago. About 1858 Col. Hunt mined from the bed several sled loads of coal, which were used for the blacksmith's forge.

The elevation of Kinear's old hunting shanty, on the summit which runs through warrants 3646 and 3564, between the headwaters of Millstone creek and Wolf run, is 1770 feet, and a quarter of a mile below this shanty, at an elevation of 1710 feet, a coal bed has been opened; when visited in 1878, the opening was closed, the top of the drift having fallen in. The thickness of the bed was reported by Mr. Nugent to be 3 feet 6 inches, composed about equally of cannelly and bituminous coal. This bed was taken to be the representative of the *Alton Upper coal*. The estimated position of the *Alton Upper bed* below the Pine Ridge opening is at an elevation of about 1680 feet, so that the dip between these two localities is toward the south-west.

All the strata through this part of Forest county have a general south-western dip, in the direction of the anticlinals and synclinals. This dip must be distinguished from the north-western and south-eastern dips, at right angles to these structural lines. It is impossible to resolve the dip between these two openings (Pine Ridge and Kinear's shanty) into the component dips in the two directions; it is probable that there is a slight synclinal between them. The coal bed at the Kinear's shanty opening is reported to have dipped into the hill. This opening was made about 1869.

The ridge on Wolf run road near Cunyngham's has an elevation of 1750 feet, and is covered by large blocks of coarse-grained white and gray sandstone, which have come from the JOHNSON RUN ROCK. The elevation at Cunyngham's is 1795 feet.(?)

North of Cunyngham's, in Gilfoyle run, the outcrop of a coal bed was dug into by Mr. Kinear about 1863. The face

of the coal was not seen here, and no report was obtained of the thickness which the bed showed, at the time that it was opened. It is probable that this bed represents the *Clarion bed*; the facts relating to it are, however, too indefinite to establish its identity absolutely. The elevation of this opening is 1780 feet.

A *bog iron-ore* is said to have been dug from the bed of the run below the opening. It is hardly probable, however, that an iron ore will be found here which can be profitably worked.

At the junction of the county roads a mile and a half beyond Cunyngham's is Byrom station, the elevation of which is 1812 feet. A short distance from the station a coal bed has been opened, at an elevation of 1750 feet. The bed is reported to be between 3 and 4 feet thick, and was opened by Mr. David S. Eldridge about 1859. The coal bed had a slaty structure and appeared to be high in volatile matter. The coal from this bed is said to resemble very much that from below Kinear's hunting shanty, the representative of which coal (*Alton Upper bed*) it probably is. The location of this opening is near the center of warrant 3801, directly east of the "*Big level*" *road.*

The elevation of the junction of the road to Beaver Meadow* is about 1820 feet. In the vicinity of the Beaver Meadow a coal is said to have been dug into, at an elevation of 1710 feet. At an elevation of 1730 feet Mr. Eldridge opened a slaty bed, which measured 2 feet 6 inches thick. This latter bed is probably the representative of the *Alton Upper*, and the coal, which is reported to have been dug into at an elevation 20 feet lower, may be the fallen down outcrop of this same bed, or it may be the horizon of the *Alton Lower bed.* The elevation of the top of the ridge immediately above the coal outcrop is 1790 feet.

The elevation of the summit at Eldridge's is 1860 feet. The summit at Eldridge's is probably underlaid by the shales which are included in the interval between the *Ferriferous limestone* and the *Clarion bed.* The general elevation of the Beaver Meadow is about 1670 feet.

* Beaver Dam tract, near head-waters of Salmon creek.

Going from Marienville north-west to Nugent's place, the road passes over a summit, beyond Salmon creek, and about a mile from Marienville, which is 1670 feet high, and is underlaid by coarse-grained sandstone and conglomerate, which is probably the representative of the lower part of the KINZUA CREEK SANDSTONE and the upper part of the OLEAN CONGLOMERATE.

Half a mile beyond this summit a second and higher summit is passed over, at an elevation of 1745 feet, which is underlaid by fine-grained friable gray and white sandstone, which represents the KINZUA CREEK. The sandstone here resembles very much some of the pink stone out of which the Presbyterian church at Kane is built.

In the western part of warrant 3177, at the old Pollard log house, the elevation is 1772 feet.* In the north-western part of warrant 3177 the elevation, of what is probably the highest point between Salmon and Little Salmon creeks, is 1810 feet. This summit is capped by the JOHNSON RUN SANDSTONE. Descending the hill toward Little Salmon creek, the surface, at an elevation of 1760 feet, seems to be underlaid by coarse-grained gray and yellow sandstone; at an elevation of 1730 feet there is a marked terrace; at an elevation of 1640 feet occurs the bottom of a large sandstone block 10 feet high and 20 feet square.

The elevation of Little Salmon creek, where the road crosses it, is 1551 feet. The elevation at Harris' house (Indian doctor) is 1790 feet, and beyond at Nugent's, 1775 feet. The elevation of the summit at Nugent's is 1840 feet, and the summit is immediately underlaid by thin, flaggy sandstone and shales, which were taken to represent those occurring above the *Clarion coal bed*. At an elevation about

*This elevation was determined by Mr. A. B. Howland with the Y level in 1882. In 1879, Mr. Sheafer determined the elevation of the same point with the barometer, as 1770 feet. Reference is made to this fact here, since it shows the accuracy of barometric hypsometry. The day during which Mr. Sheafer ran his line of barometric levels was not a favorable day for such work. The aneroid was read twice at the Pollard house, at 8.20, A. M., and 5.55 P. M. The barometer at the latter observation read 70 feet higher, by the foot scale, than in the morning, the barometer falling continuously during the day. Before Mr. Sheafer could record the absolute height of this point, a correction had to be made for this change.

the same as Nugent's, was found the outcrop of a coal bed, which had been dug into at one time, and is reported to be 2 feet 6 inches thick. This probably represents the *Alton Upper bed.*

Above this opening, at an elevation of 1815 feet, is the foot of a marked terrace, where pieces of outcropping coal were found. This has probably floated from the outcrop of the *Clarion coal bed*, which probably occurs a few feet above the upper part of the terrace flat.

There is a spring at an old deer lick, at an elevation of 1735 feet, below Nugent's, where a fire-clay is found. This is probably one of the softer strata near the center of the KINZUA CREEK SANDSTONE. In Nugent's spring, at a depth of 4 feet, 2 feet 6 inches of outcrop coal was found, the elevation of the bottom of the coal being 1765 feet. One foot below this coal another bed is reported to exist, which is 10 inches thick.

At an elevation of 1705 feet, a coal bed was opened by Mr. Nugent, in 1875, which measured 1 foot 3 inches thick on the outcrop. The dip of the bed seems to be to the northwest, judging from its outcrop, and a fire-clay apparently forms the roof. This bed represents the *Marshburg Upper coal.* Immediately below it are found blocks of the OLEAN CONGLOMERATE.

There is a south-eastern dip in the strata from Nugent's toward Hunt well No. 1, immediately west of Marienville.

On the western side of Salmon creek, near an old deer lick, about a mile and a half west of Marienville, and from 80 to 100 feet higher, the ridge has an elevation of 1600 feet, and is capped by the OLEAN CONGLOMERATE and sandstone. The pebbles in the sandstone are numerous, but irregularly distributed; more so than is generally seen in the OLEAN CONGLOMERATE. Many of the pebbles are angular, or are flattened. The sandstone layers alternating with the conglomerate beds are from 2 to 3 feet thick. Scattered on the top of the hill are large blocks of the OLEAN CONGLOMERATE 15 feet high. This formation is not as massive as the OLEAN found in the vicinity of Hickory run in Hickory township.

Immediately above the conglomerate, and in the vicinity of Hunt's well No. 1, the *Marshburg Upper bed* has been opened, at what has been known as *Towler's coal bank.*

The ridge running from Marienville south to Rose's and thence west, lying between the headwaters of Coon creek and the branches of Salmon and Tionesta creeks, is capped by one of the three sandstone members of the POTTSVILLE CONGLOMERATE. North-west of Rose's house the crop of a coal bed was dug into by Mr. Rose about 1875, at an elevation of 1700 feet, the top of the ridge being 35 feet higher. West of here the ridge hardly varies 50 feet above or below an elevation of 1700 feet.

About two miles and a half west of Rose's there is a low swampy place, having an elevation of 1620 feet, which is probably underlaid by the fire-clays and shales contained in the *Alton group.*

Kingsley and Howe Townships.

In the highest hills along the Tionesta valley, between Nebraska and Balltown, small coal beds are reported to have been opened in a number of localities. No outcrops were found, however, and no information sufficiently definite was obtained, to lead us to suppose that any bed has been found, which would have produced coal which could even be used on the blacksmiths' forge.

The highest hills seem to be capped by the OLEAN CONGLOMERATE and the lower part of the KINZUA CREEK SANDSTONE, so that, if any coal was ever dug into in this vicinity, it has probably come from the *Upper Marshburg bed.*

On the Funk heirs' tract, near one of the head streams of "the branch" of Salmon creek, which is called Coal Bank run, a coal bed was opened about 1865 by Mr. Howe. Coal was taken from this point to Balltown, and used by the blacksmiths in the mills. The section of the bed is as follows (Fig. 93, page 306):

1.	Black slate, (roof,)	10″
2.	*Coal* and slate,	3′
3.	Black slate, (fire-clay,) (floor,)	10″
	Total,	4′ 8″

The opening had fallen shut, when visited by Mr. Sheafer, but the coal is said to be very slaty and to contain considerable pyrites. The last coal was taken from this opening ing about 1870, by John Miller from Balltown. The bed is probably the representative of the *Upper Marshburg*.

The elevation of the summit in warrant 3188 is 1800 feet. This summit is probably immediately underlaid by the upper part of the KINZUA CREEK SANDSTONE. The elevation of Salmon creek, where it is crossed by the road from this summit to Marienville, is about 1625 feet.

About a mile and a half north-west of Foxburg, in the corner of warrant 2991, a coal bed has been opened, at about an elevation of 1750 feet, the section of which is reported as follows (Fig. 94, page 306):

1. Black slate, (roof,)	—
2. *Coal*,	1′ 3″
3. Fire-clay and slate,	4″
4. *Coal*,	1′ 3″
5. Hard fire clay, (floor,)	—
Total,	2′10″

This opening had fallen shut when I visited it, but I was informed that the bed had been worked under the hill for a distance of 100 feet from the outcrop. The upper bench of coal was very slaty and cannelly, and was made up of alternating bands of bright and poor coal, from $\frac{1}{16}$ to $\frac{1}{8}$ of an inch in thickness. The coal contained in the lower bench was better and more solid.

There is quite a summit 80 feet above the opening, which is underlaid by sandstone, containing coal plant impressions and fragments of plants. This sandstone is probably the representative of the KINZUA CREEK, and the bed beneath it of the *Marshburg Upper coal*.

This same bed is reported to have been opened by Mr. C. J. Fox south-east of Foxburgh. It is reported that the coal was not found as thick at this latter opening, and that it was overlaid by cannelly black slate from 4 to 5 feet thick, which is said to have burned on a hot fire. A short distance from this opening was located Fox's old hunting shanty; and the same coal bed had been opened in the brook near the shanty.

Seventy feet below the outcrop of coal at this point there is a sharp change in the slope of the hill, which was taken to mark the lowest stratum of the OLEAN CONGLOMERATE. Along the hill slope at this point were found huge blocks of sandstone and conglomerate, from the OLEAN CONGLOMERATE, measuring about 20 feet high and 20 feet on the side. The pebbles in the conglomerate were of irregular shape and in many cases had flat surfaces and were slightly angular. These shapes of the pebbles are probably these which they possessed when deposited with the other material forming the conglomerate. It has been thought by some geologists that the angularity of pebbles is produced by pressure subsequent to their deposition. This is hardly probable, since the pebbles are formed of very hard, compact quartzite and must have been when deposited as hard as they are at present.

Near the southern corner of warrant 5103, at an elevation of 1765 feet, Mr. Little opened a coal bed in 1858, which is reported to have contained 1 foot 8 inches of good coal. This is probably the *Alton Upper bed.*

Barnett Township.

The summits along the road leading from Marienville south-west to Red Cliff, in the northern part of Barnett township, are immediately underlaid by the JOHNSON RUN SANDSTONE, the elevation of the cross-roads at Red Cliff being 1615 feet. The elevation of the Marienville summit is 1805 feet, and it is capped apparently by the same rock. The distance between the two beds is about five miles, in an air-line, so that these facts would indicate an average dip in the surface rocks toward the south-west of 35 or 40 feet to the mile. It is impossible to state this dip precisely, from the fact that it would seem probable that the summit at Red Cliff is immediately underlaid by a lower stratum of the JOHNSON RUN SANDSTONE than the Marienville summit.

As far as is known, no coal beds have been found in Barnett township, but the summits are sufficiently high to contain the representatives of both the *Marshburg* and *Alton Upper beds.*

Green Township.

In the north-western part of Green township, on the Heath farm, a coal bed has been opened, at an elevation of 1720 feet, 20 feet below Heath's house. The section of this bed is as follows (Fig. 95, page 306):

1. Black slate, (roof,)	—
2. *Coal*,	1′
3. Slate and fire-clay,	1′
4. Coal,	1′ 6″
5. Fire-clay, (floor,)	—
Total,	3′ 6″

This bed was opened in the fall of 1877 by Mr. Heath, and considerable coal has been mined for local consumption. The coal contains a good deal of slate, and is splinty and cannelly. The bed, without doubt, represents one of the *Alton coals.*

The elevation of Henry Zundell's house west of Heath's is 1740 feet. At this point pieces of ferruginous sandstone are found, which are doubtless from the JOHNSON RUN ROCK. About 25 feet below the house there is a level, which would appear to be underlaid by an argillaceous shale and fire-clay of the *Alton group.*

The summit of the hill, at an elevation of 1715 feet, near Eichenberg's, is capped by a ferruginous sandstone, which would appear to represent the KINZUA CREEK ROCK (possibly the JOHNSON RUN SANDSTONE).

Between four and five miles west of Rose's the ridge attains an elevation of 1775 feet, and on its top are found numerous blocks of the JOHNSON RUN SANDSTONE from 5 to 10 feet high and from 10 to 15 feet square on the side. On the face of many of these blocks small ridges of iron stand out in bold relief. This feature is characteristic of the JOHNSON RUN SANDSTONE.

The elevation of the summit at Hazlitt's, or what is known as Oak Woods, is about 1750 feet. On what is known as the Lumber Company's upper tract, a coal bed was opened about 1870 by Mr. Guiton, which measured 1 foot 6 inches thick, and probably represents the *Alton Upper bed.*

A short distance beyond Hazlitt's, and at an elevation of

1775 feet, on what is known as the Bond lot, a coal bed has been opened on the outcrop, the section of which measured as follows (Fig. 96, page 306):

1. *Coal*,	1′ 6″
2. Black slate,	3″
3. *Coal*,	1′ 6″
4. *Coal* and slate,	2′
Total,	5′ 3″

The middle bench contained the best coal. A good deal of coal has been dug here for blacksmiths' uses.

Some distance beyond this opening, in the bed of Bear creek, a *bog iron ore* is reported to have been found, which, like the other ores already referred to, probably owes its origin to the iron being washed out of the POTTSVILLE CONGLOMERATE and deposited in a bog bed.

The elevation of the spring at Hazlitt's is about 1770 feet. Descending Little Coon creek from this point the elevation of the bridge crossing the creek near the old saw-mill is 1700 feet. Half a mile beyond this point, and at about the same elevation, was found a boggy soil containing considerable iron.

About three miles above the mouth of Little Coon creek the outcrop of a massive fine-grained sandstone, belonging to the POCONO FORMATION No. X, forms a bluff, 50 feet high, along the sides of the creek. There is a perceptible dip in the strata here west, down the bed of the stream.

The elevation of the bridge over the Tionesta at Nebraska is 1095 feet. In the higher summits, within the area just referred to between Nebraska and Marienville, the facts indicate that no coal beds exist here, other than the *Alton Upper* and *Marshburg Upper beds*, and it is highly improbable that either one of these beds will ever be found of workable dimensions or purity. It will probably not even pay to work these beds on the outcrop, as they have been done to a very limited extent in the past, for obtaining fuel for blacksmiths' forges. Since railroad communications have been obtained in central Forest, the coals which can now be shipped into the county are much better, than the coals to be found in Forest. Such coals can no doubt be

purchased at a figure much lower than the cost of digging these beds, so that it is not probable that these coals will ever be dug into again.

Tionesta Township.

Descending the valley of Tubb's run towards the Allegheny River, the bottom of the OLEAN CONGLOMERATE seems to outcrop at an elevation of 1500 feet; the aggregate thickness of the OLEAN CONGLOMERATE and the KINZUA CREEK ROCKS in the vicinity of Tionesta is probably about 200 feet.

The summit of the hill immediately west of the Allegheny River at Tionesta is underlaid by 95 feet of massive coarse-grained sandstone and conglomerate, which was taken to represent the OLEAN CONGLOMERATE. The elevation of the summit of this hill is 1595 feet, and the bottom of the POTTSVILLE CONGLOMERATE, No. XII, formation occurs at about the same elevation, both east and west of the Allegheny River, at Tionesta.

I am informed that three coal bed outcrops, besides the one referred to, have been located, on the Heath farm, in the vicinity of Tionesta. None of these were found, however, and no definite information obtained in regard to them. It is certain, that the only coal beds which it will be possible to find in this vicinity are the *Marshburg Upper* and *Alton Upper coal beds*, and, as it is highly improbable that these beds will ever be found in a condition which would render it profitable to mine them, no special search was made for these outcrops, as no reliable information could be reported in regard to them without extensive digging.

The position of the KINZUA CREEK SANDSTONE and OLEAN CONGLOMERATE in the vicinity of Tionesta are boldly defined, not only by frequent bluffs formed by their outcrop, but by the distinctive features in the profile of the hills, which they determine, so that the horizon of both of these coal beds can be easily determined by a location of the top of both of these sandstones, above each of which one of the coal beds is found. If any one should desire to search for these out-

crops, the tops of these sandstones should be located, as the points where digging should be commenced.

The highest summits in the southern part of Tionesta township are capped by the OLEAN CONGLOMERATE. Few of these summits rise to heights above 1600 feet.

Under the higher hills the *Marshburg Upper bed* may be found, although no outcrop of it was seen.

Hickory Township.

Along Hickory or Beaver Pine creek, in the northern part of Hickory township, the OLEAN CONGLOMERATE caps the hills. The elevation of the ridge immediately north of Nelson P. Wheeler's house is 1645 feet. This elevation marks what was taken to be the top of the OLEAN CONGLOMERATE. The ridge is capped by huge blocks of the OLEAN from 25 to 30 feet high and from 40 to 50 feet square.

These blocks consist of massive, loose-grained sandstone, containing small angular ellipsoidal pebbles scattered through its mass, alternating with pieces of massive conglomerate, containing pebbles from the size of a pea to that of a walnut. The lower portion of the blocks on the top of the hill are pieces of the most massive conglomerate, containing the largest pebbles. The conglomerate beds vary from 6 to 7 feet thick. Portions of the sandstone alternating with conglomerate are false-bedded and very ferruginous. On the weathered surfaces of the blocks the iron is segregated along definite lines having all possible directions, which resist the action of the atmosphere more than the other portions of the sandstone and conglomerate.

The elevation of Mr. Wheeler's house, in the valley to the south of this ledge, is 1125 feet.

Along the Allegheny River, in the vicinity of Hickory station, the elevation of which is 1092 feet, are exposed 25 feet of gray, green, and brown argillaceous shale, very much stained with iron, which exhibits a structure resembling a concretionary one, probably due to the action of the atmosphere, and which is considerably false-bedded. The geological position of these shales is in the lower part of the POCONO FORMATION, No. X.

Harmony Township.

The summits west of the Allegheny River, in Tionesta and Harmony townships, do not rise to as great a height as those to the east of the river. The highest ones seem to be generally capped by the OLEAN CONGLOMERATE, while a few were located, which probably contained portions of the KINZUA CREEK SANDSTONE. The highest elevation measured in this part of the county was the hill south-west of Copeland's farm, the elevation of which is 1680 feet. At this point a portion of the KINZUA CREEK SANDSTONE would appear to immediately underlie the surface. The summits gradually rise to the north, and in Warren county, north of Harmony township, they rise to a height of over 1700 feet, the general elevation of Fagundus being about 1700 feet.

Between Nilesburg and Fagundus a great many pebbles about the size of peas were seen in the sandstone and conglomerate. Some of these pebbles were round, others of very irregular shape. The cementing material, which holds these pebbles together in the conglomerate, is very soft and easily attacked by the weather. South of Nilesburg toward Tionesta very few pebbles were noticed in the sandstone blocks.

It is probable that the outcrop of the *Marshburg Upper bed*, between the OLEAN CONGLOMERATE and the KINZUA CREEK ROCK, may be found in certain sections of Harmony township. It was not learned, however, that the coal bed had been located here. If this bed should be found, no hopes should be entertained as to the probable existence of a valuable bed of coal.

General Conclusions in regard to the Coal Measures in Forest county.

This review of the coal measures in Forest county points to the conclusion, that, although considerable coal underlies certain areas, no beds will probably ever be found, which will contain coal of sufficient thickness or purity to make it profitable to work them, even for local consumption.

The only coal beds which have been found are, the *Clarion*, which occurs on top of the JOHNSON RUN SANDSTONE, underlying the higher summits throughout the central por-

tions of Jenks township; one of the *Alton Group beds*, occurring between the JOHNSON RUN and KINZUA CREEK SANDSTONES, underlying the higher summits throughout the county east of the Allegheny River; and the *Upper Marshburg bed*, occurring between the KINZUA CREEK SANDSTONE and the OLEAN CONGLOMERATE, underlying all the higher areas except those capped by the OLEAN CONGLOMERATE.

It has already been seen, in a review of the coal measures of Elk and Cameron counties, that there are generally two or three coal beds occurring between the JOHNSON RUN and the KINZUA CREEK SANDSTONES, embraced within an interval varying from 10 to 25 feet, the coal beds themselves being separated from one another by argillaceous shales and fire-clay. In this horizon, in Forest county, but one coal bed has been found in any one locality, and from the fact that this bed seems to underlie generally the JOHNSON RUN SANDSTONE, with only a few feet of slate and shale between, and from the fact that the *Alton Upper bed* is more regular in its occurrence than either the *Alton Middle* or *Lower bed*, this coal has been designated as the upper of the three beds. In some localities this bed may represent one of the lower beds; as to whether it does or does not, however, is a matter of no practical importance, and of very little geological interest.

Although no extensive mining enterprise has ever been attempted in Forest county, and the few coal openings which have been made have been merely outcrop diggings, many of them not going in sufficiently far to expose the solid face of the coal, yet the facts, which have been obtained from these developments, have been sufficiently definite to enable it to be asserted, that the coal which is contained under the hills of Forest county is of no practical value.*

In the description of these same coal beds in Elk and Cameron counties, it is found that they are of a sporadic character. They not only vary much in the character of the coal which they contain, but in the successive alternations of

*The commercial value of a coal bed depends upon the cost of producing the coal for the consumer, compared with the cost of coal which may be brought from other fields.

good coal with bony coal and slate, and in their thickness, sometimes thinning down to a knife edge in a short distance and permitting the roof and floor rocks to come together, the coal being absent from between the two strata over considerable areas.

By some persons it might be inferred, from the variable character of these beds, that the openings, which have so far been made, may have been at just the localities, where the beds were of poorer quality and thinner section, and that, by a further search, they might be found in other localities, where they might have a greater section and contain purer coal. The facts, however, which have already been obtained, through the developments which have so far been made, would not support such an inference. I believe that where these beds have been opened, in a number of localities, they are found at their best.

The field examinations of the coal measures, in Forest county, were made with a great deal of care, and the opinion, which is held by certain persons, that coal beds exist in the county, of workable thickness and containing marketable coal, does not seem to be sustained by the facts.

SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA.

REPORT OF PROGRESS RR.

APPENDIX A.

DRILLINGS FOR COAL

IN

SERGEANT TOWNSHIP, McKEAN COUNTY.

A CORRESPONDENCE BY

N. F. JONES, J. P. LESLEY, AND C. A. ASHBURNER.

In April, 1881, an open letter (published by the author in pamphlet) was addressed to "Sam. Q. Brown, Esq., Member of the Board of Commissioners of the Geological Survey of Pennsylvania," by Mr. N. F. Jones, who had directed certain explorations of coal lands in Sergeant township, McKean county, in which exception was taken to that portion of the report (R) on the geology of McKean county, published by the Survey in 1880, which related to these same coal lands. This letter was replied to by the State Geologist and by the author of the report, respectively, and the three letters were published in pamphlet form in May, 1881.

Further explorations and examinations, which have been made since 1881, serve to confirm the conclusions stated in the McKean report (R) and in the letters in reply to that of Mr. Jones. For these reasons, and from the fact that these letters contain additional information, not in Report R, relating to the geology of McKean county, they are republished in report RR on the adjoining counties of Elk and Cameron.

123 REID AVENUE, BROOKLYN, N. Y.,
April 12, 1881.

To SAM. Q. BROWN, Esq., *Member of the Board of Commissioners of the Geological Survey of Pennsylvania:*

DEAR SIR:

In the reports on progress of geological survey for 1880, vol. R, McKean county, that of Assistant-Geologist Mr. Charles A. Ashburner, commended by his chief, Mr. Lesley, for the "skill and carefulness" of its execution, contains at page 109 the following:

"§ 145. On the Butterfield purchase of the Backus and Chadwick lands, occupying the southwestern corner of Norwich and southeastern corner of Sergeant townships, six drill-holes have been bored to test the coal-beds. Records of five of these holes were reported by Mr. Seth Backus, of Smethport, and are published just as they were copied from the original records kept by the drillers.

"These records have been closely studied and compared with my own surface observations made on the ground.

"I regard them to be unreliable, and to show nothing from which a just opinion could be formed as to the *number*, *thickness*, or *value* of the several coal-beds which are reported to have been pierced by the drill. They are, however, published here for reference, and I have presumed to put a construction upon them to *indicate at least* the probable geologic position of the strata which have been more or less *minutely described.*

"In the vicinity of each hole I have endeavored to determine the *probable* position of the *Clermont coal-bed*, from observations made on the JOHNSON RUN and KINZUA CREEK SANDSTONES and OLEAN CONGLOMERATE."

It may be difficult to expose such a mass of errors and egotistical presumption, endorsed as it is by official sanction and State authority, but knowing your acquaintance with

my examination of the Butterfield lands in 1864 and 1865, a part of which were the drillings above referred to, and sensible of the favorable position I have long held in your esteem, it shall not be forfeited without the attempt at least to vindicate the honesty, if not the completeness, of that work.

The field notes of those drillings are not now in my possession. I left them at Smethport with Mr. Backus, and they are doubtless the ones copied by Mr. Ashburner as "the original records kept by the drillers," but his publication of what purports to be copies of them (R, pp. 110–116) is not correct, as will be shown further along.

I have before me the connected profile of wells 1, 2, and 4, showing the vertical section of each, and the strata as cut by the drill, and notwithstanding Mr. Ashburner's sneer at their *minute description* (the italics and capitals in the quotation are his), they are just what they purport to be—neither more or less than what the sand-pump produced, with such corrections as subsequent openings demanded.

It is not claimed that the sand-pumpings of a well-hole are an infallible guide to a knowledge of the strata cut, nor did I depend on them alone for my judgment in this case, but proved them by openings when openings were possible within reasonable limits of expense. And had Mr. Ashburner—as it was his duty to do before such wholesale condemnation of prior examinations—gone underground instead of depending on "surface observations" for a knowledge of stratification buried under the accumulations of a dense forest and the *débris* of friable rocks, even he might have been compelled to recognize some facts that militate against pet geological theories and generalizations.

"These records have been closely studied," says Mr. Ashburner. Now, let us see to what purpose. Doubtless they embraced also that of the Buffalo Coal Company well, drilled under the direction of Mr. Graham Macfarlane "in the vicinity of well No. 4," and for a proper illustration I have prepared the subjoined diagrams showing side by side wells 1, 2, and 4, on the Butterfield land, and the well of the Buffalo Coal Company "in the vicinity of No. 4." They are drawn to a common vertical scale and refer to the com-

mon datum of tide-water as ascertained by Mr. G. Macfarlane; but in correctly applying that datum to these wells it was necessary to change several of the figures *so carefully* given in Mr. Ashburner's report.

It is to be observed in this connection that Butterfield wells 1, 2, and 4 are all of the seven (not six) three-inch holes drilled on their lands that can be of use in this discussion, and they are not in Norwich township, as would be inferred from Mr. Ashburner's report, but in Sergeant, and in the fifth coal-basin. All of the remainder are in Norwich and in the fourth basin; but I have not preserved profiles or full detailed information as to them, and, therefore, cannot speak critically of them; nor is it necessary, for although all are embraced in the sweeping denunciation quoted, yet those in the fifth basin will probably answer the present purpose.

The geological situation in the basin, as well as the relative positions of these wells, must be kept in mind during their consideration.

They are all on the southeastern side of the axis—that is, on the northwestern dip of the measures.

No. 1 is high up on the rim, and from it to No. 4 is slightly north of northwest, distance nearly 1½ miles (7,400 feet).

No. 2 is between 1 and 4, but is slightly to the left of a direct line, being almost due northwest from No. 1, and distant 5,200 feet. It is 2,200 feet from No. 4.

All the measures have, therefore, a dip, though not necessarily of a uniform or regular descent, from 1 to 4. They, in fact, dip more rapidly as they approach the middle of the basin between 2 and 4 than between 1 and 2.

Nos. 1 and 2 are on the same plateau, and their mouths at nearly equal elevation, 2,225 and 2,229 feet, respectively, above tide.

No. 4, situated on a small dividing ridge between two branches of Brewer's Run, is lower topographically, the elevation of its mouth being 2,173 feet above tide; but it is through much higher geological ground, and has this preeminent distinction—that *it cuts a greater thickness of fertile measures and discloses more coal than is penetrated by any other boring in the fifth basin*, if not in the entire northwestern coal-field.

It may be proper here to note the "carefulness" and accuracy exhibited in some of Mr. Ashburner's figures.

He has the elevation at No. 1, Jones' datum 894+Macfarlane's difference 1,338=2,232′ of tide.
The original profile says Jones' datum =887, which + Macfarlane's difference . . . . . 1,338=2,225′ "

Error= 7ft.

At No. 2 the elevation is given Jones' datum=894+Macfarlane's difference 1,338=2,229′ of tide.
The original profile says Jones' datum =891, which + Macfarlane's difference . . . . . 1,338=2,229′ also, the tide elevation in this case being correct, but that is not due to the correctness of the figures published.

At well No. 4, without using Jones' datum, the tide elevation is called 2,200′
The original profile gives Jones' datum 834.8, say 835, + Macfarlane's difference . . . . . 1,338=2,173′

Error= 27 feet.

And that error of 27 feet is just what has led Mr. Ashburner into a great deal of his trouble over these wells. I will refer to this matter again when we get a little further along.

The Buffalo Coal Company Well.—The position of this well is fixed by Mr. Ashburner (R, p. 117) "in the vicinity of well No. 4," a very indefinite location, considering the part it has to play in his report and the share it had in determining the *utter unreliability* of the Butterfield wells.

"In the vicinity" may mean five feet or five thousand feet distant, according to circumstances. Such a looseness of expression on an important subject in a technical report manifests but little of that "*carefulness*" so much commended, and in a case of this kind is inexcusable.

I have been informed that it is nearly half a mile from No. 4, but judging from my recollections of the ground and a few notes of the topography west of No. 4, I take it to be about 1,000 feet, possibly 1,500, south of west from that

well. The levels show it to be on the line of slight ascent of the measures, and the elevation of the mouth is the same as No. 4—2,173′ of tide.

On the diagrams all the coal-seams and traces of coal in these wells are accurately marked in proper position as they were cut by the drill, so far as it is possible by careful drilling and measurement to locate them. The leading intermediate strata are also noted enough, I think, to enable any one to trace the general features of the formation, but many of the smaller divisions that would merely confuse are omitted.

Please turn to the diagrams and let us endeavor to see wherein these wells are consistent, and wherein they are not, one with the other, and with the general characteristic conditions of the northwestern coal-field of Pennsylvania.

One feature of all the basins in it is that on the geological ridge that separates them the coal veins always thin out to an unproductive seam, and sometimes entirely disappear, while the harder rocks of the measures correspondingly thicken. Another is, that towards the middle of the basin the veins generally improve in size and quality as well as in number.

Well No. 1 is high up on the saddle between the fifth and fourth basins, and it does not need the eye of a scientific geologist to perceive that there is no coal in it, but mere traces of veins, and that a single well in that vicinity is sufficent to settle all question on the subject.

The ground is too shallow in this well to afford room for more than one or two of the lowest veins, and the place for them, if it exists, is occupied by black slates within 40 feet of the surface. There is not much danger in asserting this, notwithstanding the fact that Mr. Ashburner, after his *close studies* (!) estimates the position of the Clermont bed (R, p. 113) 30 feet below the top of this well, which would bring the Upper Marshburg at 2,087′—8 feet below the bottom, among a mass of sandstones, where, I think, it would puzzle him to find a place for it—saying nothing about the disposal of four or five intermediate ones.

Without claiming sufficient geological accomplishment to

locate all the different strata in this well, I hope it will not be presumption in me to suggest that the top of the sandstone floor of the coal-measures, called by Mr. Ashburner the Olean conglomerate, may possibly be at 2,184′, and that thence with a dip of 2.06 per 100 feet to 2,077′ in well No. 2, it forms the only connection between the two that is of any account in this matter.

Well No. 2, 5,200 feet further into the basin than No. 1, shows coal-seams increased in size and number, so well marked that the intermediate sandstones are readily distinguished. The large mass that underlies all the coals, and was pierced for 106 feet without perceptible break, is beyond doubt the floor of the measures, *alias* Mr. Ashburner's Olean conglomerate—though why he should travel into another State where there is no coal to find a name for this leading feature of all the Pennsylvania coal-fields passes comprehension.

After *close study(!)* Mr. Ashburner estimates the position of Clermont bed in well No. 2 at 64 feet below the top, which would place the Upper Marshburg at 2,057′, or 20′ *into the Olean conglomerate*, burying Mr. Macfarlane's 16-inch vein of the "vicinity" well in the same grave, and with its overlying 25 feet of sandstone fill the space occupied by black slates, coal, and fire-clays.

Well No. 4 is 2,200 feet further down the side of the basin than No. 2. The increased coal development in it is undoubtedly remarkable, nor is it to be wondered at that a professor with pet theories to maintain should be staggered by it, and it may be the mere courage of ignorance that emboldens a layman to defend such an exhibit.

For more convenient reference I have lettered the coal-veins as they occur in this well.

The sandstone floor is well fixed in No. 4, as it is in No. 2, and all doubt as to its penetration at 2,005′ was removed before drilling was stopped. The mass of sandstone overlying C, 24 feet thick in No. 4, and 47 feet in No. 2, is equally conspicuous and well defined. The upper surfaces of these two belts vary from parallel but 6 feet in 2,200 feet. The increasing thickness of the upper one as it approaches the anticlinal nearly all occurs on the lower side, and re-

duces the space between them to 39 feet in No. 2, while it is 56 feet in No. 4. This space is filled chiefly with bituminous slates accompanied by fire-clays and nodules of iron ore. Interlaid with these slates are veins of coal, marked A, B, and C. In well No. 2 a small seam at 2,083′: 4′ 11″ at 2,095; and 3 feet at 2,113′; and in No. 4, vein A, 4′ 4″ at 2,018½′; B, 6′ 7″, divided by 10 inches of slate at 2,040′; an intermediate of 20″ at 2,032′; and C, 3′ 2″ at 2058′; giving for that space, as indicated by the drill, nearly nine feet of coal in No. 2 and 14 feet 11 inches in No. 4. That there is a propriety in thus treating the veins between these two lower ledges as a whole is evident upon inspection of the diagram, and is in conformity with the practice of geological experts notably that of Mr. Ashburner in his treatment of the Alton and Marshburg groups. Nor should it be taken as proof of unreliability in reported drillings when the place of the latter in two adjacent wells is found to contain more coal than has been allotted to it in any other quarter. It is undoubtedly a reason for further investigation, but scarcely for utter condemnation.

D 2′ 3″ in No. 2, and 2′ 2″ in No. 4, lies immediately on top of the second great sandstone in these wells—counting from the bottom—and its position is fixed by the back of the ledge on which it rests in almost exact parallelism with the great sandstone floor.

At 2,109′ in No. 4 and 2,181′ in No. 2 is a small seam of coal that has a dip between the two wells precisely parallel to the sandstone floor. Fourteen feet above it, in No. 4, is E 3′ 1″ thick, which has its representative in No. 2 at 2,199′ in a small seam eighteen feet above the other.

F in No. 4 at 2,150′, 2′ 10″ thick, should not, and does not, appear in No. 2. It crops out in the small valley between the two wells, and is not again under cover in that direction.

Mr. Ashburner, with *close figures* as well as *study* (!), estimates the position of Clermont bed in well No. 4 at 46′ 8″ below the top. There is a slight mistake in this also, as will be shown hereafter.

Meanwhile we pass to the Buffalo Coal Company's drill-

hole "*in vicinity*" of No. 4, a vertical section of which is given with the others and similarly lettered.

This well occupies an important position in this discussion, and doubtless held an equally important one in Mr. Ashburner's *studies*, who says of it (R, p. 117): "The boring was commenced 18′ above the *Clermont coal bed*, and the drill was pushed to the depth of 154′, stopping in the center of the OLEAN CONGLOMERATE, passing through successively the JOHNSON RUN SANDSTONE, *Alton coal group*, KINZUA CREEK SANDSTONE, and *Marshburg Upper coal bed*, which was encountered at a depth of 127′ 6″."

There are two or three notable things in this extract to which I beg to call your attention.

If it is not the duty it should be the aim of these *State* geologists to reduce the confusion of local names. Certainly they should not add to it by needlessly increasing their number and extending their range over other districts that are already well supplied with them.

The name of "*Clermont*," used in Mr. Ashburner's report, is merely a new local name given since the recent commencement of operations by the Buffalo Coal Company to a coal bed in the fifth basin, previously well known locally as Wood's Vein, and published under that title in several of the reports enumerated in Mr. Ashburner's letter on page viii and ix.

The *Alton coal group*, *Marshburg Upper coal bed*, etc., are other instances of rechristening, aggravated by the fact that they are dug out of the sporadic patches of Lafayette and transported to the well-defined coal-troughs of the fourth and fifth basins. But a much more serious fault than any of these is committed in saying that at the well in question "the drill was pushed to the depth of 154′, *stopping in the center of the* OLEAN CONGLOMERATE."

The record of Mr. MacFarlane's drilling, as published by Mr. Ashburner, has nothing in it to indicate such a termination; on the contrary, the last 22′ are through slates and fireclay only, the drill having passed through 3′ 6″ of *jet-black slate*, stopping immediately beyond in 2 feet of *gray slate;* not a word is said about sandstone or Olean conglomerate.

Judging from developments at well No. 4, it is reasonable

to believe that the slates in this one extend for about 12 feet farther, and that the Olean conglomerate is not less than that distance between the bottom of the well; to go to the "center" it would be necessary to sink about sixty feet deeper. I am sorry to say this does not manifest that exceeding "*carefulness*" in sticking to the facts that we were led to expect from the introduction to the report.

This well goes to a lower tide-level and also penetrates to a lower geological one than any other drilling by the Buffalo Coal Company, and it is much to be regretted that Mr. Macfarlane did not push it a few feet farther, until it had unmistakably entered the so-called Olean conglomerate. But two (Nos. 8 and 9) of all his other drillings reach the Kinzua Creek sandstone, and none of the remainder go beyond the "Alton bed."

Evidently this drilling is the scale by which the Butterfield wells were measured, and, with Mr. Ashburner's permission, I will use it for the same purpose—always bearing in mind that it is short at the lower end.

Correcting *official errors* (already referred to) in the tide-level of mouth No. 4, we find that it and the mouth of this one are at the same elevation, 2,173′; and when they are placed side by side my reading of the two is readily perceived on inspection of the diagram. The first vein cut, *F*, is Mr. Ashburner's *Clermont*, 3′ 1″ in this, 2′ 10″ in No. 4. *E*, 3′ 1″ in No. 4, is scattered in fragments through ten or eleven feet in this.

D, which is a compact vein of 2′ 3″ in No. 2 and 2′ 2″ in No. 4, has but 8 inches in its proper place on back of the 25 feet of sandstone in this, the remainder being pushed up as a separate vein of 1′ 6″ 13 feet above. The space between the heavy sandstone ledge and the floor, measuring 39 feet in No. 2 and 56 feet in No. 4, with its great mass of slates and coal-beds A, B, C, is equally apparent in the Buffalo well, where it would probably measure, if thoroughly pierced, about 55 feet, the coal in it, as indicated by the drill, being C=1′ 4″; B=1′ 6″, and for A 3′ 6″ of "*jet-black slate*," with at least 12 feet "yet to hear from."

Now, where is the incongruity among these wells that justifies their wholesale condemnation as "*unreliable*"?

"Close studies," if properly applied, should have given us something else, instead of such a judgment.

But the Buffalo drilling was commenced 18′ above the *Clermont coal-bed*, and I have taken *F*, nearly opposite in Well No. 4, for the same bed; while Mr. Ashburner, saying (page 110) that he has "presumed to put a construction upon" the Butterfield drillings, estimates to an inch the position of Clermont coal-bed at E in No. 4. Now the *Clermont vein* is the key that unlocks the entrance to all those wells; and that I may not be thought disrespectful in thus using it, I will give my reason for the act.

When I made the Butterfield drilling there was no "*Clermont bed*," it was the "*Woods vein*." I started well No. 4 on the top of a small ridge, at the foot of which the *Woods vein* cropped out within about 100 feet distant, and when it reached the corresponding level cut a coal-vein at 20 feet down, measuring, as nearly as we could read the drill, 3 feet thick. I subsequently drifted in from the outcrop and mined out several hundred tons of coal, clearing out a chamber from about the well where it measured 2′ 10″, and from which we could see daylight through the drill-hole. You have my reason for placing the *Woods* alias *Clermont* vein at *F*; and had Mr. Ashburner gone into that mine and looked out through the drill-hole I think he would have seen more than he found in his "*surface observations made*"—in the muck.

I have already exposed the error of 27 feet made by Mr. Ashburner in the tide-elevation at mouth of well No 4, and am sorry now to be compelled to say further that that blunder led him into the second one of fixing the place for the *Clermont* bed in that well 30 *feet too low*; in the doing of which he has been compelled to ignore the existence of *F*, that has been proved by actual opening and mining; and, instead, pins his faith to *E*, that is *below* the Johnson Run sandstone instead of *above* it, that to this day has remained hidden from actual view in all this part of the basin, and which is one of the only two in well No. 4—*A* being the other—about whose existence there may remain some doubt. But then *F* in No. 4 is of no account, for it was believed to be asserted only in those "*unreliable records of drilling*

that showed nothing from which a just opinion could be formed." Therefore, Mr. Ashburner, instead of unlocking—with the key in his hand—the front door, and descending all the successive steps into the well unobstructed, tried to force an entrance at the cellar; and see what trouble it has brought him to!

Nor is it about the Butterfield wells only that Mr. Ashburner's "*skill, carelessness, and close study*" have been at fault. There are a few things about the Buffalo Coal Company's drillings that suggest enquiry, but I will only refer to one that has some relation to the matter we have had under discussion. The records of drill-holes Nos. 2 and 7, with their accompanying diagrams (R. pp. 132 and 136,) show a vein above the *Clermont*. In No. 2 *it is 20 feet above*, 2′ 4″ thick, and 3 feet below the surface. In No. 7 *it is 26½ feet above, 2 feet thick*, and 14½ feet below the surface. The depth of No. 2 is given to nearly 87 feet, but it has below that a strata of coal and one of fire-clay of thickness not given, being probably at least 60 feet below the Clermont bed. No. 7 is 86 feet deep—41 feet below the Clermont bed. It is situated on the eastern side of the property, evidently not far from the Butterfield lands (though the line between them is not shown on Mr. Ashburner's map,) and is in the same part of the basin as Butterfield well No. 4—probably 2,000 feet from it. No. 2 is almost due west from No. 7, distance 3 miles.

In answering the question as to what this vein is that is 26½ feet above the Clermont in No. 7, Mr. Ashburner says "it is not sufficiently high in the coal series to be the *Dagus bed*," which is true; but it "may possibly be the representative of the coal which is frequently found under the *Clermont* (*Ferriferous*) *limestone*," for which supposition there is not a particle of reason given, nor is there any evidence that such a bed was ever found in this basin, in either McKean or Elk county. It is quite as probable a solution to say that it is the *Clermont bed*, and that in this, as in No. 4 of the Butterfield wells, the reading commenced too far down.

On the *extra* coal seam in No. 2, Mr. Ashburner says it "is too near the *Clermont bed* to be the representative of the *Dagus bed*. As it occurs immediately under a clay soil,

it is probably an outcrop far below the true position of the bed from which it has come;" which is not at all a reasonable supposition, for it is found on a broad plateau where the sliding of an outcrop in the manner referred to could not occur, and in just such positions as veins are frequently found of full size, in place on their normal beds, with no cover but a few feet of earth. Had the wells gone to the bottom of the measure, we could possibly have found a solution for this apparent mystery; but, wanting sufficient information, that is impossible, and Mr. Macfarlane may be thankful that his drillings have been saved by a pair of geological fancies from the sad fate that attended those on the Butterfield lands. He made a still more narrow escape at drill-hole No. 4 (R, p. 134,) where the driller was too drunk to see a vein that ought to have been there.

Probably we wretched laymen are not sufficiently regardful of these obstructions in the path of knowledge, and, instead of fault-finding, should feel grateful for our chastenings, and extol the genius of learned professors who can so readily find scapegoats—when they have a mind to—for the sins of rebellious coal-veins that are where they should not be, and are not where they should be.

It must not be supposed from what has been said in this communication that the drillings at the Butterfield wells were the *sole* reliance for the truth of the stratification they disclosed. It is well known and conceded by all who are informed on the subject that there are many things to prevent an exact measurement of the successive strata as they are cut by the drill. The most experienced hand will sometimes fail to detect a change in passing from one to another; a slight inattention on the part of the one in charge at a critical moment may lose the proper point of separation, and failure to pump out all drillings from one may apparently thicken it at the expense of the next, or pieces of coal falling from an upper vein may readily be mistaken for a lower one. To ascertain with certainty what there is in a well it is necessary to prove the drillings by exposing the measures to view, and I should have held myself as very much short of a proper examination of the Butterfield lands had I neglected to verify the drillings by openings on the

veins. Openings were therefore made which fully proved the approximate correctness of the drillings on B, C, and F, and their thickness at places opened are the ones now marked on the diagram.

A could not be opened without too expensive shafting.

E was also passed on the score of expense in view of the verifications by openings on the others, and *D* was considered as sufficiently proved, as it undoubtedly is, by the remarkable coincidence in the drilling of the two wells, and the persistent stability of the bed it rests on.

The opening on *F* has been described.

That on *B* was made by an open drift, pushed, if I remember correctly, about 50 feet under cover; and *C* was cut in a shaft sunk through it that was continued until it also penetrated *B*. In all these openings the veins were found as represented on the diagram. No man cognizant of that fact, with sense sufficient to comprehend it, could doubt the reliability of the drillings, both as "to the *number* and *thickness*," and also as some guide to "the *value*, of the veins."

Probably Mr. Ashburner did not know it. So much the worse for his judgment of utter condemnation in ignorance of the facts. In the political world it is considered dangerous to entrust judicial functions to those who would fulminate decrees without knowledge, but geologists may be a class of beings not liable to the weaknesses of ordinary mortals, and therefore privileged to such things.

Fearing to exhaust your patience, which I trust has not been too sorely tried to prevent following this to the end, I close with the hope of having succeeded in clearing from your mind any doubts that may have been excited by the publication of the gross errors I have endeavored to expose, and subscribe myself,

Most respectfully, your friend and humble servant,

N. F. JONES.

[The paging of Mr. Jones' letter has been made to agree as nearly as possible with that of his own publication.]

A reply to Mr. N. F. Jones' "Letter on drillings for coal in the Fifth Pennsylvania basin" dated 123 Reid Avenue, Brooklyn, N. Y., April 12, 1881, and addressed to Sam. Q. Brown, Esq., Member of the Board of Commissioners of the Geological Survey of Pennsylvania.

1008 CLINTON ST., PHILADA., *April 27, '81.*

DEAR SIR: Please accept my thanks for a copy by mail of your letter to Mr. Brown. Having in my preface of Mr. Ashburner's report of his survey of McKean county, endorsed it as skillfully and carefully made, it is becoming that I make the following reply to your strictures on its skill and on its carefulness.

Permit me, first of all, to repeat my personal, professional and official opinion, that in a long life as working geologist I have never known a more thoroughly intelligent, skillful, conscientious and careful survey of any district, in this or any other country, than that made by Mr. Ashburner in McKean county; and I think no one will be disposed to question my right to judge of it, since I was the first trained geologist to make a reconnaissance survey of that and the neighboring counties in 1840, and have personally made local surveys there in subsequent years. I fore-knew therefore all the difficulties to be encountered when I recommended the Board to entrust its thorough survey to Mr. Ashburner; and I knew his ability to encounter these difficulties, and the patient precision with which he would gradually overcome them. He was not restricted as to the time in which the work was to be completed and he knew how to obtain information and assistance on all sides. His admirable previous work in Huntingdon county (published in Report F) stands in evidence that he went into McKean county with an exceptionally good training for his work; and my intercourse with him through its slow and protracted progress was perfectly satisfactory.

Secondly. It grieves me to think that you could so misunderstand expressions in his report (R, p. 109,) as to suppose them "egotistical," "presumptuous," and even "sneering." These are not qualities of his character nor charac-

teristics of his style of reporting. What you take to be egotism, is merely the necessity which I have imposed upon all the members of the geological corps *to write in the first person singular*, so that it may be clearly understood by the readers of their reports, that the facts presented in a report have been personally studied by the writer of it, and that he is willing to be held responsible for what conclusions he has been able to draw from them.

What you take to be presumption, is merely that just and honest confidence with which all thoroughly conscientious, slow, well considered work inspires the worker.

What you take to be "a sneer," was the very reverse of a sneer, as you will see if you read the passage (on page 109) again with the following explanation in view. The passage is as follows:

"I regard them [the drill-records] to be unreliable, and to show nothing from which a just opinion could be formed as to the *number*, *thickness*, or *value* of the several coal beds which are reported to have been passed by the drill. They are however published here for reference, and I have presumed to put a construction upon them to *indicate at least* the probable geologic position of the strata which have been more or less *minutely* described."

Surely there could not have been penned a more modest statement by a man dealing with scientific facts and bound in duty to report his conclusions respecting them. He does not say that the records *are* unreliable; he says he *regards* them unreliable. He does not say that they teach *nothing;* he says that he must look upon them as *not* showing what in his opinion can be taken as a just basis for determining certainly the actual *number* of coal beds in the column; the actual *thickness* of those coal beds, and the actual *value* (or quality) of the coal in them.

He does not reject the whole set, or any one of them, and throw them in the waste basket, as many a field geologist has thrown aside or silently ignored the work of others which he could not fit to his own; he *publishes* them, in his report, so that if he be mistaken in his judgment, others

may have a fair opportunity to use them and arrive at better conclusions.

He does not even pronounce dogmatically upon their value;—he uses the word "presume" in the universal English manner to express the fact that he wishes to guard against "presumption:"—"I have presumed (I have ventured) to put a construction upon them."

So far from an "egotistic, presumptuous" expression of a positive opinion, sneeringly opposed to that of others, he adds: "I have presumed to put a construction upon them to *indicate at least* the probable geologic position of the strata which have been more or less *minutely described.*"

What less could he have said? How more carefully could he have guarded his language against offence? He had to *at least indicate*, or suggest some harmony between these records and others; and that is all he would presume or venture to do.

And here let me say that you have been very naturally and justifiably misled by the use of italics in this sentence. You have supposed that certain words in it were italicised to express the author's *feelings* towards you and your work. But if you will glance through this and other reports of the survey you will see that I have caused them to be printed *full* of italicised words; not at all to express sentiment; but to catch the reader's eye when he was turning over the leaves to find some subject or fact. They are also used as in this sentence to mark the *important* words. They save a world of explanation, and diminish the size of a volume.

The italics "*number, thickness and value*"—"*indicate at least*"—"*minutely described*" have nothing whatever to do with the question whether the facts under discussion are true or false, worthless or valuable; and still less to do with any opinion respecting the author or authority of the facts. They are merely catch words to indicate the matter in debate. "*Indicate at least*" is italicised for emphasis, to show that at least some indication of the right conclusion can be gotten from the facts.

You seem to be especially aggrieved at the italicised expression "*minutely described,*" thinking it "a sneer." But

you will be relieved of any such suspicion if you will read Mr. Carll's report, and what he says, (and what we all know) of how much the scientific value or availability of a well record depends on its minuteness ; and how few of the many thousands of well records have been a near approach to the sense of the term minute. So far from Mr. Ashburner sneering at your well records as only pretending to be minute, he intimates that they are *not* to be rejected on that score ; they are *not* mere skeleton records ; they are "more or less *minutely described.*" He could not say "*minutely described*," for that would not be true, as you are yourself well aware. But it is part of his precise information to the reader that they were "more or less minutely described."

I have dwelt on the *animus* of this report, because it is a vital matter. No geological survey can perform its duty to the State, unless it publishes *all* the facts and its best conclusions from them. But if the language in which it publishes be open to the suspicion that the State geologists go about from county to county in a supercilious, dogmatical, sneering, fault-finding, depreciating, "high-toned" mood ; the facts which it publishes will not be accepted by the people as facts ; and its conclusions will be regarded in the light of snap-judgments, or pig headed prejudices. Fortunately all that sort of nonsense is knocked out of us by a few years of survey work carried on over wide areas, and under the critical eyes of hundreds of local experts, whose past work we soon learn to treat uniformly with respect and attention, and whose opinions when contrary to our own must never be contradicted, in a spirit less worthy than that in which they are held.

But you will pardon me for assuming that a geologist who has spent half a dozen years in doing nothing else but studying half a dozen neighboring districts must needs acquire great intelligence and skill in his work, and that if he makes blunders they are likely to become smaller and smaller, while the ease and confidence with which he comes to right conclusions must constantly increase. Nothing disciplines to carefulness and precision like a succession of difficulties, and nothing frees a mind so completely from

prejudices as studying a great variety of allied and neighboring scientific phenomena.

Thirdly. Your attack upon Mr. Ashburner is therefore not too rude considering the impression you were under, that his report was intended to dishonor your work and profession as an expert.

But that impression has naturally made your letter somewhat intemperate in tone, and thereby diminishes its force as an argument. Good reasoning may sometimes be done by one in anger; but most persons feel less confidence in it than if it be dispassionately stated. There was no just cause for anger in this case, as I have already shown.

But there are other disqualifying passions besides mere heat of temper, which hinder the popular reception of even sound argument. One such is especially obnoxious to well trained field workers in our science, viz: a passion for *exaggerating* some facts at the expense of others; and for *overstating* local laws of structure, as if they were general laws. Any man who does this respecting his own field of observation is sure to be looked upon as not sufficiently well informed outside of his own locality to be an unimpeachable or reliable observer inside of it. I will explain more clearly what I mean, because it will help a good deal towards getting the just weight and value of your criticisms on Mr. Ashburner's report. You say, for instance, on the third page of your letter, and put it in italics:—Bore-hole "No. 4 * * * has this preëminent distinction that *it cuts a greater thickness of fertile measures, and discloses more coal than is penetrated by any other boring in the fifth basin*, if not in the entire northwestern coal-field."

I do not deny this statement, for nothing ought to be denied until it is disproved. But it certainly sounds like one of those exaggerations, which characterize coal-company reports,—perfectly honest exaggerations, but not the less unreliable because honest. This question is not at all respecting the mining engineer's or geologist's honesty. The question is wholly respecting the accuracy of his well-record,—whether the *boring tools* are honest in what they report. Everybody knows that boring-tools are not thoroughly re-

liable record-makers, and the reasons why they are not are described at full length in Mr. Carll's Report III.

It would be strange indeed if this No. 4 bore-hole should have this "preëminent distinction." It would not be strange to find *one local very thick bed of coal* here; for such exceptional deposits are met with in other places, in western Pennsylvania. But it is remarkable enough to excite a desire for better evidence than a well-record to find so many 3′ and 4′ coal beds in one local section of only 170′. This is all that Mr. Ashburner meant by "unreliability." Let a shaft be sunk and each reported coal bed be examined and measured, and black and dark slates be rejected from the list of coals, and we shall then have a "reliable section." Until then nothing can be confidently asserted or denied respecting it. Mr. Ashburner does not speak of the "*utter unreliability*" of the Butterfield wells, as you intimate on your fourth page. He does not use the word "*utter*." That is an exaggeration of your own feelings towards him.

You say, on page 5, "One feature of all the basins in it [northwestern coal field of Pennsylvania] is that on the geological ridge that separates them the coal veins always thin out to an unproductive seam, and sometimes entirely disappear, while the harder rocks of the measures correspondingly thicken."

No doubt you have seen instances of this. If you would extend your observations over the whole area, you would see more instances of the same sort; but you would see as many more instances of *just the reverse;* where the coals are thin in the troughs and thicken as they rise to pass over the anticlinals. You have exaggerated a local phenomenon into a general law. But there is no such general law. It is only around the edges of the original coal swamps where this thinning occurs. It has nothing whatever to do with the synclinal troughs and anticlinal rolls which pass across western Pennsylvania.

If you wish to see a proof of this I refer you to one not far from McKean county, the Renovo coal basin, where numerous borings along the middle of the basin have only

found a few inches of coal, while the outcropping beds on each side, on the rise towards the anticlinals are thick enough to work. One single instance like this breaks down your law. How then can you expect the readers of your letter to consider you a more reliable geologist than Mr. Ashburner, when a question of facts arises between you?

Be good enough to look carefully over the reports of Messrs. Stevenson, White, W. G. Platt and Chance, covering sixteen of *the coal counties* of western Pennsylvania, and see if you can find the slightest trace of such a law. I assure you that it has no existence except in your own mind. It does not exist in nature. The Pittsburgh bed and other beds dip down into the troughs and ride over the anticlinals without their thickness and value being in the slightest degree increased by the one or diminished by the other. And indeed why should they be affected by them any more than the thickness and value of a pile of carpets be changed by crumpling it into folds?

But when you add—"and in number," I confess that I am impressed by the audacity of your generalization—I say it in entire respect to yourself; for I know how it comes about. You have seen one or two places where an additional coal bed has come in between two others, and accidentally on the down dip; or a bed has split in that direction (accidentally) and its two benches been removed to some distance from each other. But let me assure you that I know many instances of that same thing occurring (accidentally also) on the uprise, out of the basin. Your mistake is in turning a few such local instances into a general rule. But if you yield to the strong temptation to such exaggerations of the facts with which you happen to be best acquainted, do not get angry with an experienced geologist like Mr. Ashburner when he finds himself reluctantly obliged to only half credit your bore-hole observations.

As for the facts of levels, intervals and thicknesses concerning which you and Mr. Ashburner disagree I refer you to his own letter of explanation.

I remain, with very great respect,

Yours truly,

J. P. LESLEY.

Reply of Chas. A. Ashburner to a letter of Mr. N. F. Jones, addressed to Sam. Q. Brown, Esq., Member of the Board of Commissioners of the Geological Survey of Pennsylvania.

907 WALNUT STREET,
PHILADELPHIA, *April 29, 1881.*

Mr. N. F. JONES, *123 Reid avenue, Brooklyn, New York:*

DEAR SIR: During a personal interview had with Prof. Lesley and Mr. Sam. Q. Brown this morning, my attention was for the first time called to an open letter addressed by yourself to "Sam. Q. Brown, Esq., Member of the Board of Commissioners of the Geological Survey of Pennsylvania," in which you have critically reviewed that portion of my geological report on McKean county, treating of what I have called the "Butterfield purchase of the Backus and Chadwick lands, occupying the southwestern corner of Norwich, and the southeastern corner of Sergeant townships."

The personal attack which you have made against "the skill and carefulness" in the execution of my McKean survey, accorded me by one of the best and most impartial judges of geological work, it is not my purpose to answer; nor do I care to deny the fact that you may indeed have found it "difficult to expose such a mass of errors and egotistical presumption, endorsed as it is by official sanction and State authority," as those which you have accredited to my published report.

As regards the logical methods, the rhetorical rendering, the typographical style, which I have employed in my report, in common with other survey assistants, under the direction of the State Geologist and with the approval of the Publication Committee of the Board of Commissioners, it would be unbecoming in me, to express either condemnation or approval.

The facts presented in your letter have been "*closely studied*," and it is my present purpose to endeavor to correct your misstatements and erroneous conclusions.

That the connection, between your letter and my reply,

may be clearly understood, I have chosen to adopt a rather illogical method, and shall attempt to meet your objections in order. I must ask your indulgence for a number of unavoidable repetitions.

(See page 2, ¶ 1, of your published letter.)

The field memorandum books in which the records of the drillings were kept, are still in my possession; they were obtained from Mr. Graham Macfarlane, to whom they had been loaned by Mr. Seth Backus. My "*publication of what purports to be copies of them*" is correct, and you are at liberty to compare them with the originals, if you think it worth while to call at my office. It will be noticed that there are slight disagreements between the sections published in your letter and those contained in my report. As your sections do not agree *exactly* with those reported by the men who did the drilling, I must demand that a preference at least be given to "my publication of what purports to be copies of them."

Further on I have given some of the more prominent points of the records, in the original wording of the drillers.

(¶ 3.) Through instructions received from Prof. Lesley "*it was my duty*" to collect and collate all previously determined facts, to make surface observations, and to go underground, within the limits of time and expense, before expressing an opinion as to the economic geology of any coal tract, and this I have done in my examination of the Butterfield tract. The fact that I have published the records of the Butterfield wells is sufficient evidence that I have "*recognized some facts that militate*" not "*against pet geological theories*," for I have none, but against an unbiased judgment.

In regard to the Buffalo Coal Company's well drilled under the direction of Mr. Graham Macfarlane "*in vicinity of well No 4*," the record was obtained from Mr. Macfarlane and copied from the original notes kept by the driller, Mr. John Morgan. The elevation of the well mouth of 273 feet above Macfarlane's datum (2173 feet above tide) was determined by his engineer Mr. Tate. The difference of 1900 feet between his datum and tide level, was estimated by my-

self from the profile of the McKean and Buffalo railroad in Superintendent S. V. Godden's office at Smethport.

(Page 3, ¶ 1.)

I do not understand how you could have inferred from my report that wells Nos. 1, 2 and 4 were in Norwich instead of Sergeant township. I state that these wells are on lands occupying the southwestern corner of Norwich and southeastern corner of Sergeant township, (page 109.) On the geological map of the county in the atlas of my report, the exact position of these wells Nos. 1, 2 and 4 is shown in Sergeant township and in the Fifth Bituminous coal basin.* I have published the records in my report of Norwich because the greater part of the Butterfield lands lie in this township. If you will refer to my county map you will find the exact position, of all of your six wells shown, which with the Buffalo Coal Company's well makes seven. The position of the wells was determined from the maps of your own original surveys drawn to a scale of 400 feet to one inch, still in my possession. I have also in my possession several of the transit and level books of your Butterfield surveys.

(¶ 4). Well No. 4, as shown on your own map, which I am informed is the only map which has ever been constructed from your field notes, is 6,475 feet north 32° west † of well No. 1 instead of 7,400 feet northwest as you state.

(¶ 5). No. 2 is 4,400 feet instead of 5,200 feet as you state northwest from No. 1. It is 2,200 feet from No. 4.

(¶ 6). The dip between wells Nos. 1 and 2 is greater than that between 2 and 4, which is the reverse of your statement. This might be naturally inferred from an examination of the position of the wells on the county map. The line between wells Nos. 2 and 4 is nearly on the strike, while that between Nos. 1 and 2 directly on the dip.

(¶ 7 & 8 page 3 and ¶ 1 and 2 page 4). As to the elevation of the wells. On your original map the elevation of No. 1 is 894 feet above your datum, which, added to Macfarlane's difference of 1338 feet, makes the elevation of the top of the well above tide 2232 feet, instead of 2225 feet, as you state.

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* See foot note Report R, page 96.

† The direction I have protracted from the map.

The elevation of No. 2 on your map is given as 891 feet, which added to Macfarlane's difference of 1338 feet makes 2229, the same as you state. This is the tidal elevation given in my report. There is a typographical error in Report R, page 112, in 894 being placed for 891; this however does not affect the tidal elevation, which is given correctly.

On your map the elevation of No. 4 is given as 835 feet, which, added to Macfarlane's difference, would make its height above tide 2173 feet as given in your letter. In my report I state that the elevation of the well mouth above ocean in feet is 2200±feet (± means more or less). My reason for adopting this latter elevation was as follows. According to Mr. Macfarlane the Buffalo Coal Company drilled a well in the vicinity of No. 4, or as I remember him to have told me, certainly within a hundred feet of it.* You were misinformed when told that this well was nearly half a mile from No. 4, and you must have erred in judgment and recollection when you "take it to be 1,000 feet, possibly 1,500, southwest from that well (No. 4), seeing it is within 100± feet of it.

Mr. Macfarlane stated that the top of his well is 273 feet above his datum or (273 + 1900) 2173 feet above tide. In this latter well the bottom of the Clermont bed was passed through at depth of 21′ 2″, which makes the elevation of the Clermont coal bed above tide 2152 feet, as stated in report R, page 117.

At the time I wrote report R, and when I "*closely studied*" these records, I "*presumed*" "*to indicate at least*" the fact that the bed which you struck at a depth of 46′ 8″ was the Clermont bed, and if it were such it should have very nearly the same elevation as the *undoubted Clermont bed* struck by the drill in the Buffalo Coal Company's well at an elevation of 2152 feet (this is the bottom of the coal bed). In systematizing the facts for my report however I have allowed a probable dip in the coal bed of 2 feet, between the two wells, and have placed the elevation of the bottom of what *I have ventured* to call the Clermont bed in the Butterfield well at 2150 feet. This would make the top

* I have been informed by Mr. Macfarlane since April, 1881, that these two wells were not over 10 feet apart.—C. A. A.

of the well 2200± feet (2150′ + 49′ 9″=2200′±) above tide. Now you may ask what were the reasons that induced me *to venture* to call the second coal bed, struck in the Butterfield well, the Clermont bed instead of the first? I will explain. On *your own map* of the Butterfield tract I found that your well No. 4 is located 725± feet southeast of the Wood's vein opening. I found also the following elevations:

"Well No. 4"	835′
"Wood's V"	796′
Difference	39′

In one of your level books which I have, I find, in what I am told is Mr. Mason Morrison's handwriting, whom I am informed was the engineer who ran the levels, the following note:

"Surface of Hole No. 4"	839.4′

Two pages following this I find (in your handwriting (?)):

"Top of Conductor Well No. 4"	834.78′
"Surface of ground " " ""	833.5′

From the former level:

Well No. 4	839.4′
"Wood's V"	796. ′
Difference	43.4′

From your notes I had no means of ascertaining the dip of the strata from the "Wood's vein" opening to your Well No. 4. From the Buffalo Coal Company's well No. 4 to the Wood's vein opening the dip was:

Top well No. 4 (B. C. C.)	273′	(M's datum)
To Clermont bed (bottom)	21′ 2″	
Elevation bottom Clermont bed	252	" "
Wood vein opening	244	" "
Difference	8′	= dip in Clermont coal bed.

Now as this dip is so small I did not "*presume*" to even estimate the dip from your data. On the assumption that there was *no dip* in the bed from your well No. 4 to the Wood's vein opening, the second bed in the well would certainly, most nearly approach the position of the Clermont bed opened at the Wood's vein opening, than

the first bed in the well. The depth of the second bed below the top of the well is 46′ 8″ and the difference in the level of the top of the well and the Wood's vein opening as shown by your map and note book is either 39′ or 43.4′. In view of these facts and this reasoning am I to be censured *in presuming to indicate at least*, that the coal bed struck at a depth of 46′ 8″ was the Clermont bed?

From the computed elevation of the Clermont bed (?) in your well No. 4 of 2150 feet the top of the well would be (2150+49′ 9″) 2200± feet. Now you may ask why did I accept this computed elevation in preference to that given by yourself (835+1338) of 2173 feet. For this reason. Mr. Macfarlane's levels I had examined both in the field and office with himself and his engineer Mr. Tate and I was satisfied as to their correctness. Your levels I have only examined as far as your results are placed on your map and in your note books in my possession. I would not presume to accuse you of error, for, as far as I know of your work and reputation, I believe you to be *a gentleman of honor and an engineer whose work can be depended upon as honest and conscientious.* My duty as an assistant geologist was to weigh the value of the two levels, that determined through Mr. Macfarlane's data, and that given by yourself. As the level of 2173 feet of B. C. Co.'s well No. 4 was scrutinized with the assistance of Mr. Macfarlane and Mr. Tate, it was accepted, and I *presumed* to place my computed elevation of 2200, more or less, as the elevation of your well No. 4, but no word of condemnation was uttered in regard to your work. Had our appropriation permitted, I should have liked to have covered McKean county with a net-work of levels before commencing my geological work, but, as this was absolutely impossible, I was compelled to accept the *best levels* I could obtain from private parties.

Mr. Macfarlane connected his drill hole No. 4 with the Wood's vein opening and settled beyond a doubt that the coal which he struck at a depth of 18′ 1″ and the Wood's vein were the same.

I am glad now to have the additional information which you state on page 10 of your letter, which is as follows:

"I started well No. 4 on top of a small ridge, at the foot of which the *Wood's vein* cropped out within about 100 feet distance, and when it reached the corresponding level cut a coal-vein at 20 feet down, measuring, as nearly as we could read the drill, 3 feet thick. I subsequently drifted in from the outcrop and mined out several hundred tons of coal, clearing out a chamber from about the well where it measured 2′ 10″, and from which we could see daylight through the drill hole."

Your statement clears up a difficulty in my work and I am only too willing to acknowledge my error. In view of your evidence, *the first coal struck in the well must be the Clermont coal bed.* This accounts for the discrepancy of 27 feet and shows that the elevation of No. 4 is 2173 feet instead of 2200 feet. My mistake, however, would appreciate rather than depreciate the value of the Butterfield tract as a coal property; for it is evident that the property would have contained more coal, had the second bed been the Clermont instead of the first bed. You can hardly judge me severely for this error, for I say "*I have*" only "*presumed to indicate at least the probable geologic position of the strata.*"

I fear I have taxed your patience with my long explanation, but as this is the only error which I can admit, that I have made in my report on the Butterfield tract, I wished you to fully appreciate the fact, that the conclusion, stated on 2 lines report R page 110, was only arrived at, after all the many facts which I could obtain had been very *closely studied.*

You are certainly mistaken, when you say that this "*error of 27 feet is just what has led Mr. Ashburner into a great deal of trouble over these wells.* If your No. 4 well had been placed 54 feet too high instead of 27 feet, as you had justly claimed, it could not possibly have affected my conclusions; it would only have necessitated a greater estimate of dip; but, as I have not even attempted to estimate the dip of the coal beds on the Butterfield tract in my report, it certainly could not have influenced any of my very few generalizations in regard to the property.

On page 4 of your letter you say "*On the diagrams* (accompanying your letter) *all the coal seams and traces of coal in these wells are accurately marked in proper position as they were cut by the drill, so far as it is possible by careful drilling and measurement to locate them.*"

It is not necessary for me to try and prove to you how far *it is possible* to locate a coal bed, to determine its thickness, its character, and its value, in a 3 inch hole, bored with an ordinary spring pole and jump drill, and the drillings scooped out with an ordinary ladle or sand pump. Every practical geologist knows how much such evidence is worth. In my private professional practice I have always refused to report on the money value of coal lands, from the records of holes bored by a jump drill and spring pole, with manual power, unless I could be on the ground and superintend the drilling through every inch of the coal bed; even with every precaution it is possible to devise, great risks are taken.

I do not hold you personally responsible for the records of the drill holes on the Butterfield tract, nor could I, unless you should assure me of the fact that you were on the ground and personally superintended the drilling and sand pumping through every inch of coal reported in the records. My criticism of these records on page 110 of my report does not reflect discredit on the integrity or honesty of your work as an engineer, full credit for which I believe is due you.

When I say "I regard them [the records] to be unreliable, and to show nothing from which a just opinion could be formed as to the *number*, *thickness*, or *value* of the several coal-beds which are reported to have been pierced by the drill," I would wish to assert that the records are unreliable, because facts have been reported in them, which I believe was done, with an intention on the part of the drillers to deceive, or what is more probable, through their ignorance.

The only facts which I hold you *personally* responsible for in my report (page 110) are the elevations. If however you consider yourself responsible for all the facts reported in the records, I would certainly question your ability and judgment as a geologist and prospecting engineer.

I do not wish to discuss the accuracy of the records of the

drill holes bored on the Butterfield lands, but I wish to call your attention to portions of the records as copied exactly from the memorandum books of the drillers and compare them with the records published on the diagram accompanying your letter.

These records are kept in the handwriting of Mr. Ellis Griffith, who seems to have been the boss driller for all the three wells except the last 6′ 1″ of well No. 4, which it appears was drilled by Mr. Beckwith.

The words in the second column in brackets and italics are in a different handwriting from Mr. Griffith's, and, as it resembles that on your map and in your note books, I infer that it is your own.

Butterfield well No. 1.

From your Diagram.		Totals.	*From Driller's Note Book.*
Earth, ... Slate, ...	20′	20′	
Iron ore, ...			Down 20 feet struck Hard Rock Red Sand 2 inches thick.
Black slate, . . — Iron ore, . . 4′	21′	41′	At 38 feet Red Sand Rock very Grity. Down 42 feet do. do. do.
White sandstone, . .	21′	62′	
Small seam coal, ...			Down 62 feet Struck Slate All most Coal At 61 feet. (*small seam of coal.*)
Iron ore, ...			At 61½ feet Iron ore.
Sandstone, . 21′ Slates, ... 6′	27′	89′	
Seam of coal, . . .			(*90 feet—a dark slate with particles of coal.*)
Total depth, ...		130′	At 130′ 4″ from surface of ground suspended drilling.

The elevation of this well in the note book is given as 887 feet above your datum; on your map it is given as 894 feet. This latter elevation is the one I have used in report R.

Butterfield well No. 2.

From your Diagram.		Totals.	*From Driller's Note Book.*
Earth, ... Sandstones, . . . Slates, ...	17′	17′	
Particles of coal, . .			(*At 17 feet struck black slate which continues to 20 pumping show a few small particles of coal.*)

Small vein coal, . .	13′	30′	A few Small Lumps of Coal in the pumping At 30½.
Yellow sandstone, Fire-clay, . . .	18′	48′	
Small coal seam, . .			At 48 Struck Soft Slate Rock, (*with small seam of coal,*) Mixt with Mud.
Slates and fire clay,	16	64′	Struck Coal At 64, This must Be Wright for We Burnt evry 6 Inches. Thickness of vain 2 feet 3 Inches.
Coal D, ...	2′ 3″	66′ 3″	
Grey and buff sandstone, &c., ...	47′	113′ 3″	
Coal C, ...	3′	116′ 3″	Struck Coal At 113+2 Down 114+2. This is Better Coal than the firs We Struck this vain Is 2 feet 9 inches thick.
Slates, ...	13′	129′ 3″	
Coal B, ...	4′ 11″	134′ 2″	At 129 Slate With A Little Coal Mixt I think this Might All Be Called Coal It Shows As Much Coal As Slate & A Littel More this vain Is 4+11.
Fire-clay with iron ore, ...	12′	146′ 2″	Most Mud Down 143. Still Soft.
Small vein coal, . .			(*at 146 small vein of coal.*)
			(*Stopped drilling in well No. 2 at 279.0 feet below top of conductor= 278.0 from surface=+612.*)

No. 2, 279 feet deep.

Griffith's note book gives the elevation of this well+891 above your elevation, same as on map. This is the elevation I have used in report R.

Butterfield well, No. 4.

From your Diagram.		Total.	*From Driller's Note Book.*
Earth, ... Slates, ...	20′		
Coal F, ...	2′ 10″	22′ 10″	At 19½ Struck Coal vain 2+10 then Soft
Wh. Sand Rock, . .	27′	49′ 10″	Rock Dark Colour till
Coal E, ...	3′ 1″	52′ 11″	38 feet then Sand Stone very Grity this Burns till 46+8 then struck Black Shale then Coal 6 Inch then White Shale White As Milk.
Wh. Sandstone, . .	12′	64′ 11″	
Small seam coal.			(No mention of coal in book
Grey Sandstone, .	7′		In this well the tools became fast at 79 feet, and a new hole was started along side of old one.
Black Slate, ...			
Wh. Sandstone, . .	6′	22′ 86′ 11″	
Fire Clay, ...			In the record of the new well following notes are found: C. A. A.)
Slate, ...			46+8 Struck Coal vain three feet 1 Inch . . (*at 64 ft. small vein and slate.*)

Coal D, . . . 2′ 2″		89′ 1″	85′ 5″ slate With A Littel Coal Mixt but not to Amount to Any thing. (This is in Griffith's handwriting, but it has been crossed out and the following written) (*85′ 5″ coal very hard and clean*) this vain as near as I can tell Is 2 feet 1 Inch.
White sandstone, ... 24′		113′ 1″	At 111 Struck Coal vain 3+2
Coal C, . . . 3′ 2″		116′ 3″	
Dark slate rock, ... 11′		127′ 3″	
Coal, . . . 1′ 3″			
Slate, . . 10″	6′ 7″ B		
Coal, . . 4 6″		133′ 10″	Down 128+7 Soft Coal vain 3 ft 1 Inch then sulphur
			Down 131+10 hard (?) Slate Dark
Slate and Fire Clay, 7′		140′ 10″	
Coal, ... 20″		142′ 6″	At 138 feet 6 Inches Struck Coal this vain Is 20 Inches thick
Black slate, ... 9′		151′ 6″	
Coal A, ... 4′ 4″		155 10″	At 149+11 Struck Coal vain . . this vain Is 4 feet 4 Inches
Cannel shales, . . 12″		156′ 10″	
Iron ore, ... 1′		157′ 10″	(*164′ 4″ Struck Iron ore Griffith stopped at 164½ ft* *Iron ore is about 6 in thick* *Total depth 170½ feet.*)

No. 4, 170 ft. deep.

I would like you to carefully compare these two series of facts; the first series is vouched for by yourself in your letter to Mr. Brown, the second series is copied exactly, with all the spelling and capitals, from the note books kept in the handwriting of Ellis Griffith, who was the boss driller at all the wells. The last 6 feet 1 inch of well No. 4 was drilled by Mr. Beckwith.

Only one of these two can be correct. Which will you select as the correct one? My condemnation of the second record, which is the one published in report R, may after all prove a fortunate circumstance for yourself.

I want especially to call your attention to the records of well No. 4. In your diagram you show a coal bed (F) 2′ 10″ thick, 20 feet below the top of the hole. Mr. Griffith reports this bed of the same thickness, but the top of it is only 19½ feet down.

The bottom of Bed E in your section is 52′ 11″ (20+2′ 10″ +27′+3′ 1″) below the top of the well by adding up the intervals and only 50 feet (2173—2123) by the difference

of elevations given. Which is the correct distance, I am unable to say. As will be observed in your record of No. 2, the summation of intervals and the difference in elevations agree down to a depth of 146 feet (bed B), where my comparison stops; therefore in your section of well No. 4 I have used your intervals in preference to the elevations.

In the first hole drilled at No. 4, which had to be abandoned on account of fast tools at a depth of 79 feet, Mr. Griffith reports only 6 inches of coal near 46′ 8″ the place of your bed E, but says that he *got a sandstone very gritty which burns*. Is this your coal bed E, which you report 3′ 1″ thick?

In the report of the second well, drilled right along side of the first well which was abandoned, Mr. Griffith's notes state that a "Coal vain three feet 1 inch" was struck at 46′ 8″ A most remarkable improvement in the productiveness of the coal bed, within a few feet, the distance between the wells. At a depth of 64′ 11″ your section shows small seam of coal. This Mr. Griffith does not report. Coal bed D in your section is 2′ 2″ thick and was struck at a depth of 86′ 11″. In Mr. Griffith's notes I find the following in his own handwriting.

"85 5 Slate With A Littel Coal Mixt but not to Amount to Anything." This however has been scratched out by some one and the following is placed immediately under, in the only other handwriting found in the book and which agrees exactly with the handwriting found upon your map: "85 5 coal very hard and clean;" after this is added in Mr. Griffith's handwriting, "this vain as near as I can tell Is 2 feet 1 Inch." The least I can say in regard to the information to be had bearing upon your coal bed D, is that it is rather contradictory and certainly confusing.

In your section coal C is found 3′ 2″ thick at a depth of 113′ 1″. Mr. Griffith's report says "At 111 Struck Coal vain 3 + 2." Here the discrepancy is only 2 feet in depth.

Your coal bed B you place at a depth of 127′ 3″; it is 6′ 7″ thick and consists of 2 benches separated by 10″ of slate. Mr. Griffith reports "Down 128+7 Soft Coal vain 3 ft. 1 Inch, then sulphur; Down 131 + 10 hard (?) Slate Dark."

The sulphur can not be very thick, for the bottom of the coal bed would be (128′ 7″ + 3′ 1″) 131′ 8″ and 2″ below at 131′ + 10″ he says dark slate. Why this disagreement between the two sections, I do not know, but the value of a property would certainly be different, if a bed, which you say contains (1′ 3″ + 4′ 6″) 5′ 9″ of coal, had only in reality 3′ 1″; as stated by the driller of the well from whose record you *must have drawn* your conclusion.

At a depth of 151′ 6″ you place your bed A with a thickness of 4′ 4″. Mr. Griffith's book contains the following: "At 149 + 11 Struck Coal vain . . . . . this vain Is 4 feet 4 Inches."

You will notice in your section an iron ore 1′ thick at a depth of 157′ 10″. In Mr. Griffith's book I find the following note, but not in his handwriting:

"164 4.

168 9. Struck Iron ore.

169 ft. Griffith stopped drilling in Iron ore."

"Error in this measurement 4½ feet, Griffith stopped at 164½ feet. Iron ore is about 6 in. thick. 165 enter grey sandstone floor of coal measures." The information here seems to be extremely conflicting. I wish to call your attention to your criticism upon the value of the record of Well No. 4 (see your letter bottom page 3.) You say:

"No. 4 —— has this preëminent distinction—that *it cuts a greater thickness of fertile measures and discloses more coal than is penetrated by any other boring in the fifth basin*, if not in the entire northwestern coal-field."

If your section discloses the rocks as they might be observed in a shaft sunk at well No. 4, it has certainly all that you claim for it. I do not think that my rejection of your opinion, under the existing conditions, is presumptuous, for since June, 1876, my occupation has been to study the coal measures of "the fifth basin" and the northwestern coal field."

But, Sir, the "scale by which the Butterfield wells were measured" (page 9 of your letter) was a comparative study of these wells, such as I have made in preparing this letter, and not Mr. Macfarlane's well, as you have intimated. In

view of these facts, am I to be blamed for my criticism of the value of these wells (page 109 report R), which you quote on the first page of your letter?

In conclusion, it would not be pertinent for me to review your condemnation of the construction which I have placed upon the records of the wells drilled on the Buffalo Coal Company's lands and reported by their former superintendent, Mr. Graham Macfarlane, but I do wish to call your attention to two facts: 1st. I regard the record reported by Mr. Macfarlane to be as reliable as is possible for a record of a hole bored with a jump drill and spring pole to be. Mr. Macfarlane has reported no coal in these records, except those beds drilled through under the personal supervision, on the ground, of himself or his engineer, Mr. Tate. My personal estimation of these gentlemen has been such that I have been perfectly free to accept as *facts* whatever they have been willing to report. 2nd. The *close study* which I have made of these records was done chiefly in Mr. Macfarlane's office.

Finally, I wish to explain to you why I have introduced into the nomenclature of the rocks of McKean, Cameron and Elk counties the following local geographical names: Dagus coal bed, Clermont limestone, Clermont coal bed, Johnson run sandstone, Alton coal group, Kinzua creek sandstone, Marshburg upper coal bed, Olean conglomerate, &c., &c.

"During the past thirty years numerous local surveys in McKean county have been made, by geological experts, in the employ of private individuals or companies, for developing the mineral resources of the region, and their reports have been printed and widely circulated.

It was not my business in this report to criticise or review professional opinions thus published, whether relating to geological facts or property values. I can only say, that the region is one of great difficulty; that the natural exposures are scarce and widely separated; that only the lowest of the coal measures exist, and these are variable; and that it would be impossible for the most thoroughbred geologist to succeed, in a short examination of one locality. In fact,

it was only after a slow, patient, and very protracted survey of the whole area, after the collation of all kinds of facts from every locality in it, and after the comparison of a multitude of sections in all four counties, that I reached conclusions on which I could rely with confidence." (Preface R, page viii.)

As all of these reports contain local and different names for the same stratum, in different parts of McKean county, I could not adopt the names used in one locality by one class of persons, without greatly confusing persons in other localities, who in some cases used the same names for entirely different strata.

As the relationship of the coal measure rocks of McKean county, with those long named along the Allegheny river to the southwest, had not been satisfactorily established, I proposed to Prof. Lesley the provisional adoption of the names in my report, until such a connection should be finally established.

The several strata were named after the place where they were best known by the greatest number of persons.

Thus your "Woods vein" was named Clermont, because the coal bed had been found to be a good commercial coal at Clermont and had been extensively mined there. Olean conglomerate was so named, because its best exposure was at Olean Rock City, &c., &c.

Regretting the necessity of being obliged to discuss your letter publicly,

I remain, Sir,

Very respectfully, yours,

CHAS. A. ASHBURNER,

Geologist in charge of the Survey of McKean county.

APPENDIX B.

NOTES ON IRON ORE IN CAMERON COUNTY.*

By CHARLES A. ASHBURNER.

A diligent search has been made in this, as well as in McKean, Elk, and Forest counties, for an iron-ore which could be profitably mined, shipped, and used in the manufacture of iron. While concretions of carbonate of iron have frequently been found in the coal measures and highly ferruginous rocks, and in exceptional cases, carbonate and brown hematite masses have been found in the strata exposed below the coal measures, none of these have come from well-defined or extensively-deposited ore beds.

The only stratum which has been discovered, which, in a number of localities, may be considered to be an iron-ore, lies immediately under the OLEAN CONGLOMERATE, or the bottom of the POTTSVILLE FORMATION No. XII, and between it and the MAUCH CHUNK RED SHALE No. XI. This stratum almost always contains more or less iron throughout the entire bituminous coal fields. It has seldom been found anywhere to contain an iron-ore bed of sufficient thickness and purity to make it pay to work it.

There seems to be but little doubt that this iron-ore bed will not be found in Cameron county, to contain a workable ore from which it would be possible to manufacture iron economically.

* Examinations made in field June, 1884.

The MAUCH CHUNK RED SHALE No. XI, the POCONO No. X, and the CATSKILL No. IX FORMATIONS, which are exposed above water level in the county, (see geological map of Cameron county, Plate III in the atlas,) have not only been thoroughly explored, more particularly by the Cameron Coal Company, but they have been subjected to the closest scrutiny wherever they have been found to outcrop in the State. The search has always met with failure, and, although the exploration of these formations in Cameron county may not warrant the assertion that they do not contain any commercial iron-ore bed, yet the facts which have been developed by these explorations, when studied in conjunction with examinations of the same formations elsewhere, certainly give sufficient data for predicting financial failure in any attempt to find an iron-ore bed which would pay for working.

Certain of the more highly ferruginous strata of the CATSKILL FORMATION in Cameron county have been mistaken for valuable iron-ore beds. The reason that the Catskill rocks are red is that they contain iron, the percentage of iron varying from 2 or 3 per cent to 10 or 15 per cent. The higher percentage of iron does not constitute the stratum which contains it, an iron-ore. Lithologically, such a rock is said to be ferruginous.

The horizon marking the contact of the MAUCH CHUNK RED SHALE and the OLEAN CONGLOMERATE in this section of the State is characterized by special features which render it easy of recognition to any geologist who is experienced in the stratigraphy of the district. The stratum at this horizon may be a fire-clay, as in the vicinity of Benezette; a black slate, as in the vicinity of Clermont; or even a coal bed, as in the vicinity of Ridgway; an iron ore bed, as in many cases in eastern Elk and Cameron counties; or, finally, a yellow argillaceous ferruginous shale, the latter being the most common occurrence.

Topographically, this geological horizon is generally marked by a distinct change in the slope of the hills, the more usual feature being a flattening of the hill slope below

the bottom of the OLEAN CONGLOMERATE. Sometimes, however, a reverse profile is found, and the hill slope below the bottom of the conglomerate is steeper than that above it. At first thought these differences in the hill slopes would seem to render it impossible to recognize the horizon, from the character of the topography in its vicinity. The differences may be accounted for by the dip of the conglomerate and the way in which the erosion has taken place. The profile of the hills, whether steepening or flattening below the bottom of the conglomerate, serves as a guide in locating the lower limit of the conglomerate.

Whatever be the distinctive character of the stratum immediately under the conglomerate, the strata for some distance underneath it are more argillaceous than the conglomerate itself and more impermeable to water. As a consequence, springs are frequently found marking the bottom of the conglomerate; swamps sometimes occur where level ground exists immediately below the springs.

In the vicinity of the town of Cameron, an iron-ore bed immediately below the OLEAN CONGLOMERATE and above the MAUCH CHUNK FORMATION No. XI is the common occurrence.

The Cameron Coal Company has opened this bed in a number of localities, and the ore bed has a more constant thickness, and contains a higher percentage of iron, than in any other locality in the county. It would not be safe, however, to conclude, from the development which has been made, that this ore bed could be profitably mined at any one point.

It is probable that the percentage of metallic iron in the output of any one opening, even when carefully prepared, would not be sufficiently high for the ore to bear shipment to distant furnaces. The erection of any furnaces in the county for the consumption of this ore would be the height of folly. If a more extensive and richer ore bed should be found, upon which a local furnace could depend for the bulk of its supply, this ore bed could probably be mined in favorable localities and be used as a mixing ore. As these

latter conditions, however, do not exist, there seems to be little hope of making a profit out of this iron-ore bed.

On Oak Hill, north of the left hand branch of Hunt's run, and at a distance of about a mile and a half from the town of Cameron, this bed has been opened at what is known as *opening No. 2*, at an elevation of 1345 feet above tide, the elevation of Cameron station being 962 feet. The rocks at the face of the drift were not solid. The ore bed was from 1 foot 8 inches to 2 feet thick, the upper 10 inches of which was a gray, sandy, ferruginous shale, from which a great deal of iron had apparently been leached by atmospheric influences. The elevation of the flat summit above this opening is 1435 feet, the summit being apparently underlaid by the top of the KINZUA CREEK SANDSTONE, the middle sandstone member of the POTTSVILLE No. XII. If this flat had been 15 or 20 feet higher it would probably have been high enough to have included a small area of the *Alton Lower coal bed*, which is found in the vicinity of the plane of the Cameron Coal Company.

The ore at *opening No 2*, is composed of gray carbonate of iron (nodules) covered generally by a thin coating of the sesquioxide of iron. This ore in its native condition is generally a bluish gray and lead-colored protocarbonate of iron, sometimes massive, breaking into square pieces, and at other times of a slaty or laminated structure. Where the ore has been freely subjected to atmospheric action, the change to brown peroxide of iron is generally complete. The earthy particles, originally contained in the carbonate, which has undergone this conversion, are generally held in the interior of the shell of peroxide. This earthy portion forms a gray dust when dried, and when moist a tenacious clay. When the ore has not been freely exposed to the atmosphere, the conversion is only partial. In this latter case, a solid nodule of iron carbonate forms the interior of the lump of ore, while the peroxide occurs on the surface as a crust of greater or less thickness. These latter characteristics are generally those of the ores found in this district.

The same ore bed has been opened on the hill to the

north of Canoe run, about a mile and a half west of the Cameron Coal Company's coal shutes. At this locality the ore was opened in two places by Mr. John Morris, Superintendent of the Cameron Coal Company, in 1871, the horizontal distance between the two openings being between 400 and 500 feet. The western opening, at an elevation of 1370 feet above tide, was re-opened in the summer of 1883, and a drift driven into the bed for a distance of 125 feet. The thickness of the ore is 3 feet, a stratum of conglomerate forming the roof to the drift. The ore at this opening was of better character than at any other visited. The second opening, from 400 to 500 feet east of this, has an elevation of 1365 feet.

On the east side of the P. & E. R. R., and north-east of the top of the Cameron Coal Company's plane, a bed has been opened at what is known as the "*D*" *opening*. In the vicinity of this opening the bed has been proved at 6 different points along its outcrop, within a distance of a quarter of a mile. The thickness of the bed ranges from 2 feet 6 inches to 4 feet. In the vicinity of the extreme eastern opening, a coal bed was found which measured 2 feet 8 inches thick, and, as nearly as could be judged, was between 3 and 4 feet beneath the ore bed. This coal bed is, without doubt, the representative of the *Lower Marshburg bed*. The opening had fallen shut when I visited it; judging from the character of this coal bed seen in other localities, it would probably not prove here a bed which could be profitably mined.

About 150 feet east of the "*D*" *opening* referred to above, a shaft was sunk 16 feet to the same ore bed, which measured 2 feet in thickness. At this point the ore, being sufficiently protected from atmospheric influences, consisted almost entirely of pure carbonate of iron. The elevation of the "*D*" *opening* is 1425 feet, and the top of the shaft 1440 feet. But a short distance north of this locality an old coal drift was found at an elevation of 1430 feet. The drift had fallen shut, and no definite information could be obtained as to what coal was found. The drift,

without doubt, marks the outcrop of the same bed to which reference has already been made.

This ore bed was also visited at what is known as the *West opening*, along the same hill slope. At this point a drift had been driven in on the bed to a distance of 50 feet, but the strata were not found solid. The elevation of this opening is 1260 feet. It is not far from the center of the *Cameron coal basin.*

It is reported that 19 feet below the ore bed at this point 3 feet of a ferruginous red shale was found by shafting. This same red shale was found at an elevation of 1590 feet on the R. Penn Smith hill south-east of Cameron station, the dip of the strata from this latter locality to the *West opening* being 350 feet. About 20 feet above this red shale on the R. Penn Smith hill a carbonate ore was found, the elevation of top of the hill above this point being 1700 feet.

It is not believed that iron-ore could be profitably mined from any of the prospect openings above described. The ore which had been dug from the openings prior to my examination in June, 1884, was not of that character to warrant a chemical analysis.

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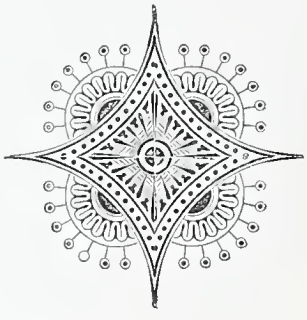

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AC. ATLAS containing 25 plates illustrating coal mining, to accompany Report AC, by H. M. Chance. 8°, 1883. Price $1 40, postage $0 12.

AA. First report of progress of the anthracite survey; PANTHER CREEK BASIN, by C. A. Ashburner; with a determination of the latitude and longitude of Wilkes Barre and Pottsville, by C. L. Doolittle; and a theory of stadia measurements, by A. Winslow. 8°, pp. 407, 1883. Price $0 58, postage $0 18.

(**AA.**) ATLAS of SOUTHERN anthracite field, Part I, containing 13 sheets: 3 mine sheets, 3 cross section sheets, 3 columnar section sheets, 1 topographical map sheet, and 1 coal bed area sheet, relating to the PANTHER CREEK BASIN; 1 general map of the anthracite region, and 1 chart of anthracite production from 1820 to 1881. 8°. 1882. Chas. A. Ashburner, Geologist in charge; A. W. Sheafer and Frank A. Hill, Assistant Geologists. Price $1 50, postage $0 12.

(**AA.**) ATLAS of WESTERN MIDDLE anthracite field, Part I, containing 11 sheets: 4 mine sheets between Delano and Locust Dale, 3 topographical sheets between Quakake Junction and Mount Carmel, and 4 cross section sheets. 8°,

NOTES.—Single sheets of the Anthracite Survey, with the exception of those in the Panther Creek atlas, can be purchased by addressing Chas. A. Ashburner, Geologist in Charge, 907 Walnut street, Philadelphia. See page 9.

1884. Chas. A. Ashburner, Geologist in charge; A. W. Sheafer and Bard Wells, Assistant Geologis's. Price $1 65, postage $0 11.

(**AA.**) ATLAS of NORTHERN anthracite field, Part I, containing 6 mine sheets between Wilkes Barre and Nanticoke, 3 cross section sheets, and 4 columnar section sheets. 8°, 1885. Chas. A. Ashburner, Geologist in charge; Frank A. Hill, Assistant Geologist. Price $, postage $.

(**AA.**) GRAND ATLAS, DIV. II, Pt. I, 1884, port-folio containing 26 sheets (26″×32″) as follows: 13 sheets Atlas Southern Anthracite Field, Part I, 11 sheets Atlas Western Middle Anthracite Field Part I, 1 sheet photo views of plaster models in Western Middle and Southern Fields, and 1 specimen sheet Report A 2. Price $4 25, expressage from Harrisburg $.

For anthracite coal in SULLIVAN county, see G 2.

For Conglomerate beds near Carbondale, Pittston, &c., see G 5, G 7.

For Utilization of anthracite slack, see M 2.

For single sheets see page 9.

BITUMINOUS COAL FIELDS AND SURROUNDING AREAS.

H. First report on CLEARFIELD and JEFFERSON counties, by F. Platt. With 8 maps, 2 sections, and 139 cuts in the text. 8°, pp. 296, 1875. Price unbound $1 50, postage $0 13 (*For second report see H 6, H 7.*)

H 2. Report on CAMBRIA county, by F. & W. G. Platt. With 4 maps and sections and 84 cuts in the text. 8°, pp. 194, 1877. Price $1 00, postage $0 12.

H3. Report on SOMERSET county, by F. & W. G. Platt. With 6 maps and sections and 110 cuts in the text. 8°, pp. 348, 1877. Price $0 85, postage $0 18.

H 4. Report on INDIANA county, by W. G. Platt. With a colored geological county map and 87 cuts in the text. 8°, pp. 316, 1878. Price $0 80, postage $0 14.

H 5. Report on ARMSTRONG county, by W. G. Platt. With a colored geological county map, and 58 cuts in the text. 8°, pp. 338, 1880. $0 75, postage $0 16.

H 6. Second report on JEFFERSON county, (*See H above,*) by W. G. Platt. With a colored geological county map, and 57 cuts in the text. 8°, pp. 218, 1881. Price $0 60, postage $0 12.

H 7. Second report on CLEARFIELD county, (*see H above,*) by H. M. Chance. With a colored geological county map, an outcrop map of the Houtzdale basin, and 58 cuts in the text. 8°, pp. 197, 1884. Price $0 85, postage $0 11.

I. Report on VENANGO county, by J. F. Carll. The geology around Warren, by F. A. Randall. Notes on the comparative geology of N. E. O., N. W. Pa. and W. N. Y., by J. P. Lesley. With one small map of the Venango oil region; one small map of the region south and east of Lake Erie; one long section of the rocks at Warren; and 7 cuts in the text. 8°, pp. 127, 1875. Price in paper, $0 60, postage $0 05.

I 2. Report of oil well records and levels in VENANGO, WARREN, CRAWFORD, CLARION, ARMSTRONG, BUTLER, &c., by J. F. Carll. 8°, pp. 398, 1877. Price $0 60, postage $0 18.

I 3. Report on the VENANGO, WARREN, CLARION, and BUTLER OIL REGIONS; descriptions of rig, tools, &c.; survey of the Garland and Panama conglomerates, &c.: discussion of preglacial and post glacial drainage; by J. F. Carll. With 23 page plates, and an atlas. 8°, pp. 482, 1880. Price (of volume and atlas together) $2 30, postage $0 30.

(I 3.) Atlas of 22 sheets. Map of Venango county, colored geologically; map of lower oil field (Butler, Armstrong and Clarion) in 2 sheets; 3 local contour maps at Franklin, Titusville, and Spring creek; two maps of N. W. Pennsylvania showing the past and present drainage; long section across W. Pennsylvania; vertical section of the formations from the Upper Coal Measures down to the bottom of the Devonian; diagram map and section of Third sand; profile section from Meadville, S. W.; 5 sheets of grouped oil well sections; 5 sheets of working drawings for well boring, &c.; diagram of daily rate of drilling six wells at Petrolia. (*Sold only with the report.*)

I 4. Report on Warren county, by J. F. Carll. With a colored geological county map, a map of the Warren oil region, and 2 sheets of oil well sections. 8°, pp. 439, 1883. Price $1 12, postage $0 20. (*Note. The first 147 pages of this book contain oil well records; see under Petroleum Fields below.*)

J. Report on the Oil Region, by H. E. Wrigley; map and profile of line of levels through Butler, Armstrong, and Clarion, by D. J. Lucas; map and profile of Slippery Rock creek, by J. P. Lesley. 5 maps and sections, a plate and 5 cuts. 8°, pp. 122, 1875. Price in paper $0 75, postage $0 06.

K. Report on Greene and Washington counties, by J. J. Stevenson. With two county maps. (Showing the calculated local depths of the Pittsburg and Waynesburg coal beds beneath the surface,) and 3 page plates of general sections. 8°, pp. 419, 1876. Price, in paper, $0 65, postage $0 16. (*Note.—Since the publication of this book, two colored geological county maps have been published, and will be found in pocket of volume K 3 described below.*)

K 2. First report on Fayette, Westmoreland, and S. E. Allegheny counties, (*i. e.* west of Chestnut ridge,) by J. J. Stevenson. With 3 colored geological county maps, and 50 cuts in the text. 8°, pp. 437, 1877. Price $1 40, postage $0 20.

K 3. Second report on Fayette and Westmoreland counties, (the Ligonier valley,) by J. J. Stevenson. With 4 page plates, and 107 cuts in text. 8°, pp. 331, 1878. Price $1 40, postage $0 16. (*Note.—In a pocket in this volume will be found the colored geological maps of Greene and Washington counties, alluded to above.*)

K 4. Pt. I, Report on the Monongahela river coal mines, from the West Virginia State line to Pittsburgh, (including some on the Youghiogheny and other streams.) by J. Sutton Wall. With a map of the region in a pocket, 12 heliotype pictures, and 26 page plates. 8°, pp. 231, 1884. Price $1 15, postage $0 14.

L. Report on the Youghiogheny coke manufacture, by F. Platt; Notes on the coal and iron ore beds, by C. A. Young; Report on methods of coking, by J. Fulton, (*See G* below;) Report on the use of natural gas in the iron manufacture, by J. B. Pearse and F. Platt; The Boyd's hill gas well at Pittsburg, by J. P. Lesley. With a map of the coke region, two folded plates of coke ovens, and page plates and cuts in the text. 8°, pp. 252, 1876. Price $1 00, postage $0 13.

Q. Report on Beaver, N. W. Allegheny, and S. Butler counties, by I. C. White. With 3 colored geological county maps, and 21 page plates of sections. 8°, pp. 337, 1878. Price $1 40, postage $0 20.

Q 2. Report on Lawrence county, and special Report on Correlation of the Pennsylvania and Ohio coal beds, by I. C. White. With a colored geological county map, and 134 cuts in the text. 8°, pp. 336, 1879. Price $0 70, postage $0 15.

Q 3. Report on MERCER county, by I. C. White. With colored geological county map, and 119 cuts in the text. 8°, pp. 233, 1880. Price $0 60, postage $0 11.

Q 4. Report on CRAWFORD AND ERIE counties, by I. C. White. With two colored geological county maps, and 107 cuts in the text. Also, a Report on a preglacial outlet for Lake Erie, by J. W. Spencer. With two maps of the Lake region. 8°, pp. 406, 1881. Price $1 17, postage $0 18.

R. Report on McKEAN county, and its geological connections with Cameron, Elk, and Forest counties, by C. A. Ashburner. With 33 page plates of vertical and columnar sections, pictures of Rock city and Olean conglomerate, Wilcox and Kane spouting wells, map of Howard Hill coal field, &c., and an atlas of 8 sheets. 8°, pp. 371, 1880. Price of Volume and Atlas together $1 70, postage $0 22.

(R.) ATLAS for McKean county of 8 sheets:—Colored geological county map; three topographical maps; of Buffalo Coal Company tract, Alton coal basin, and Potato Creek coal basin; map of McKean oil district; one sheet of columnar sections between Bradford and Ridgway; and 2 diagram sheets of the Well account and Production account in the Bradford district. (*Only sold with Report R.*)

R 2. Part II, Report on township geology of CAMERON, ELK AND FOREST counties, by C. A. Ashburner. (*To appear about March 15, 1885.*)

(R 2.) ATLAS for CAMERON, ELK AND FOREST counties, of 11 sheets (*published November, 1884, in advance of the report*):—3 colored geological county maps; 1 anticlinal and synclinal map; 1 topographical map McKean county; 2 tract maps Forest and Elk counties; 1 map Straight Creek coal basin; 2 sheets oil well sections; and 1 sheet coal sections. Price $0 65, postage $0 08.

V. Report on N. BUTLER county; and (Part 2) special report on the Beaver and Shenango river coal measures, by H. M. Chance. With a colored geological map of N. Butler; a contour local map around Parker; a map of the anticlinal rolls in the 6th basin; a chart of the Beaver and Shenango rivers; profile section from Homewood to Sharon; Oil well records and surface sections; and 154 cuts in the text. 8°, pp. 248, 1879. Price $0 70, postage $0 15.

V 2. Report on CLARION county, by H. M. Chance. With a colored geological county map; a map of the anticlinals and oil-belt; a contoured map of the old river channel at Parker; 4 page plates, and 83 cuts in the text. 8°, pp. 232, 1880. Price $0 43, postage $0 12.

For the coal basins of BRADFORD and TIOGA counties see report G.
For the coal basins of LYCOMING and SULLIVAN see report G 2.
For the coal basins of POTTER county see G 3.
For the coal basins of CLINTON county see G 4.
For the coal in WAYNE county see G 5.
For the East Broad Top coal basin in HUNTINGDON county see F.
For the mountain coals in BLAIR county see T.
For the Broad Top coal measures in BEDFORD and FULTON counties see T 2.
For the coal basins in CENTRE county see T 4.
For coal analyses, see M, M 2, M 3.
For classification of coals, see in M 2.
For coal plants, see P, P 2.
For fossil crustaceans in coal slate, see P 3.

PETROLEUM AND GAS.

See reports I, I 2, I 3, I 4, and J under Bituminous Coal Fields.

See L, for the Pittsburgh gas well, and the use of gas in the iron manufacture.

See Q, Q 2, Q 3, Q 4, for references to oil rocks in Beaver, Lawrence, Mercer, Crawford, Erie, and S. Butler counties.

See K for the Dunkard creek oil wells of Greene county.

See R, R2, for descriptions of oil rocks in McKean, Elk, and Forest counties.

See V, V 2, for notes on the oil rocks of N. Butler, and Clarion counties.

See H 2 for oil boring at Cherry Tree, Cambria county.

See G 5 for oil boring in Wayne county.

NORTH-EASTERN AND MIDDLE PENNSYLVANIA.

(Palæozoic formations from the Coal down.)

D. First report on LEHIGH county iron mines, by F. Prime. With a contour line map of the ore region, and 8 page plates. 8°, pp. 73, 1875. Price in paper $0 50, postage $0 04.

D 2. Second report on LEHIGH county iron mines, by F. Prime. With a colored geological contour line map of the iron region, (in 4 sheets,) a colored geological contour line map of the Ironton mines, 4 double page lithograph pictures of Limestone quarries, and one page plate of *Monoeraterion.* 8°, pp. 99, 1878. Price $1 60, postage $0 12.

D 3. Vol. 1. Report on LEHIGH and NORTHAMPTON counties. Introduction, by J. P. Lesley; Slate belt, by R. A. Saunders; Limestone belt and iron mines, by F. Prime; South mountain rocks, by F. Prime and C. E. Hall. With 3 lithograph pictures of quarries, 4 pictures of triangulation stations, 14 page plates of sections, and an atlas of maps. 8°, pp. 283, 1883. Price $0 65, postage $0 13. (*Note, for atlas see below.*)

D 3. Vol. II, part I. Report on BERKS county, (*South Mountain belt,*) by E. V. D'Invilliers. With 10 page plates of sections and Indian relics, and 3 pictures of rock exposures. 8°, pp. 441, 1883. Price $0 55, postage $0 18. (*Note, for atlas see below, as before.*)

(**D 3.**) ATLAS: One colored geological map of *Lehigh* and Northampton counties, (*one sheet*); one colored geological contour line map of Southern Northampton county, (*six sheets*); a contour line map of the mountains from the Delaware to the Schuylkill, (*eighteen sheets*); a colored geological contour line index map to the 22 sheets, (*one sheet*); and 4 sheets of maps of Iron mines. Price of Atlas $2 80, postage $0 17.

D 5. ATLAS of colored geological county maps of CUMBERLAND, FRANKLIN, and Adams, (*three sheets*); and first instalment of contour line map of the South mountains, Sheets A 1, A 2, B 1, B 2, (*four sheets,*) by A. E. Lehman. Price of Atlas $1 25, postage $0 08.

F. Report on the JUNIATA RIVER district in MIFFLIN, SNYDER and HUNTINGDON counties, by J. H. Dewees; and on the Aughwick valley and East Broad Top region in HUNTINGDON county, by C. A. Ashburner. With colored geological maps of East Broad Top R. R. and Orbisonia vicinity (2 sheets); Three Springs map and section (2 sheets); Sideling Hill creek map and section (2 sheets); and Isometric projection at Three Springs (1 sheet); six folded cross sections and 22 page plates of local maps, and columnar sections. 8°, pp. 305, 1878. Price $2 55, postage $0 20.

F 2. Report on PERRY county, (*Part I, geology,*) by E. W. Claypole. With two colored geological maps of the county; 17 geological outline township maps as page plates; and 30 page plate cross and columnar sections. 8°, pp. , 1884. Price $, postage, . (*In press, October, 1884.*)

G. Report on BRADFORD and TIOGA counties, by A. Sherwood; Report on their coal fields (including forks of Pine creek in Potter county), by F. Platt; Report on the COKING of bituminous coal, by J. Fulton. (*See L above.*) With 2 colored geological county maps, 3 page plates, and 35 cuts in the text. 8°, pp. 271, 1878. Price $1 00, postage $0 12.

G 2. Report on LYCOMING and SULLIVAN counties: field notes by A. Sherwood; coal basins by F. Platt. With 2 colored geological county maps (of Lycoming and Sullivan), a topographical map (in two sheets) of the Little Pine creek coal basin, and 24 page plates of columnar sections. 8°, pp. 268, 1880. Price $1 06, postage $0 14.

G 3. Report on POTTER county, by A. Sherwood. Report on its COAL FIELDS, by F. Platt. With a colored geological county map, 2 folded plates, and 2 page plates of sections. 8°, pp. 121, 1880. Price $0 58, postage $0 08.

G 4. Report on CLINTON county, by H. M. Chance; including a description of the Renovo coal basin, by C. A. Ashburner; and notes on the Tangascootac coal basin, by F. Platt. With a colored geological county map, 1 sheet of sections, local Renovo map, 6 page plates, and 21 sections in the text. 8°, pp. 183, 1880. Price $1 05, postage $0 12.

G 5. Report on SUSQUEHANNA and WAYNE counties, by I. C. White. With a colored geological map of the two counties, and 58 cuts in the text. 8°, pp. 243, 1881. Price $0 70, postage $0 12.

G 6. Report on PIKE and MONROE counties, by I. C. White. With two colored geological county maps, (1 sheet Pike and Monroe, and 1 sheet Wyoming,) a map of glacial scratches, and 7 small sections. Report on the Delaware and Lehigh water gaps, with two contoured maps and five sections of the gaps, by H. M. Chance. 8°, pp. 407, 1882. Price $1 15, postage $0 15.

G 7. Report on WYOMING, LACKAWANNA, LUZERNE, COLUMBIA, MONTOUR, and NORTHUMBERLAND counties, (*i. e.* the parts lying *outside* of the anthracite coal fields,) by I. C. White. With a colored geological map of these counties, (in two sheets,) and 31 page plates in the text. 8°, 464, 1883. Price $0 85 and postage $0 20. (*Note.—The colored geological map of* WYOMING *county is published in G 6.*)

S. Report on the Seven mountains in HUNTINGDON, UNION, AND SNYDER counties, by C. E. Billin. With a colored geological contour line map of the mountains (1 sheet); maps of the fossil ore outcrops, and Stone mountain fault; and colored geological cross sections, (2 sheets.) 8°, pp. , 1885. Price $, postage $. (*In press.*)

T. Report on Blair county, by F. Platt. With 35 cuts in the text, and an Atlas of maps and sections, (See below.) 8°, pp. 311, 1881. Price *with atlas* $4 55, postage $0 28.

(**T.**) ATLAS of colored geological contour line map of Morrison's cove, Canoe valley, Sinking valley, and country west to the Cambria county line, (14 sheets); Index map of the same (1 sheet): colored sections, (2 sheets.) 8°, 1881. (Note.—*The Atlas is not sold separately.*)

T 2. Report on BEDFORD and FULTON counties, by J. J. Stevenson. With two colored geological maps of the two counties. 8°, pp. 382, 1882. Price $0 80, postage $0 20.

T 3. Report on HUNTINGDON county, by I. C. White. With a colored geological map of the county; and numerous sections. 8°, pp. , 1885. Price $, postage $. (*In press.*)

T 4. Report on CENTRE county, by E. V. D'Invilliers; also, special report by A. L. Ewing; and extracts from report to Lyon, Shorb & Co., by J. P. Lesley. With a colored geological map of the county, 13 page plates of local maps and sections, and 15 cuts in the text. 8°, pp. 464, 1884. Price $0 80, postage $0 19.

See also report on the line of the Terminal Moraine, Z.

SOUTH-EASTERN PENNSYLVANIA.

C. Report on YORK and ADAMS counties, by P. Frazer. With one folded map of a belt of York county through York and Hanover, 6 folded cross sections, and two page plate, microscopic slices of dolerite. 8°, pp. 198, 1876. Price in paper $0 85, postage $0 10. (*Note.—The colored geological county map of* YORK *is published in the* ATLAS *to C 3.*)

C 2. Report on YORK and ADAMS counties, (South Mountain rocks, iron ores, &c.,) by P. Frazer. With one general map of the district; 10 folded cross sections; and 5 page plates. 8°, pp. 400, 1877. Price $1 25, postage $0 12. (*Note.—The colored geological county maps of* ADAMS *is published in* D 5.)

C 3. Report on Lancaster county by P. Frazer. With nine double page lithographic views of slate quarries, and Indian-pictured rocks; one plate of impressions on slate and one page plate microscopic section of trap; and an atlas. 8°, pp. 350, 1880. Price of report and atlas $2 20, postage $0 25.

(C 3.) ATLAS of 13 sheets:—Colored geological map of YORK county; colored geological map of LANCASTER county; Susquehanna river section (Sheets 1, 1A, 2, 2A, 3, 4); Lancaster section; Pequea section; Muddy run section; Chestnut-hill mines; Gap nickel mine. (*Note.—Atlas sold only with report.*)

C 4. Report on CHESTER county; General description, pp. 214, by J. P. Lesley; Field notes in the townships, pp. 215-354, by P. Frazer. With a colored geological county map, a photographic view of contorted schists, and 12 page plates. 8°, pp. 394, 1883. Price $0 75, postage $0 18.

C 5. Report on DELAWARE county, by C. E. Hall. With a colored geological county map; a contour line map around Media; 30 photographic page-plate views of granite quarries Kaolin pits, &c., and 4 page plates of altered micas. 8°, pp. , 1885. Price $, postage $. (*Partly printed; but publication delayed.*)

C 6. Report on PHILADELPHIA and the southern parts of MONTGOMERY and BUCKS counties, by C. E. Hall. With a colored geological map of the belt of country between Trenton and Delaware county (in 3 sheets); a sheet of colored cross-sections, and 24 cuts in the text. 8°, pp. 145, 1882. Price $1 65, postage $0 13.

E. Part I of (historical introduction to) a report on the AZOIC rocks, by T. S. Hunt. 8°, pp. 253, 1878. Price $0 48, postage $0 12.

VOLUMES PUBLISHED AND ON SALE, MARCH 1, 1885.

A.	D 2.	H 7.	P atlas.
A 2.	D 3, Vol. I.	I.	P 2.
AC.	D 3, Vol. II, part I.	I 2.	P 3.
AC atlas.	D 3 atlas.	I 3.	Q.
AA.	D 5 atlas.	I 3 atlas.	Q 2.
AA atlas (1.)	E.	I 4.	Q 3.
AA atlas (2.)	F.	J.	Q 4.
Grand atlas, Div. II, Pt. I.	G.	K.	R.
	G 2.	K 2.	R atlas.
Grand atlas, Div. I, Pt. I.	G 3.	K 3.	R 2 atlas.
	G 4.	K 4, Pt. 1.	T.
B.	G 5.	L.	T atlas.
B 2, (exhausted.)	G 6.	M.	T 2.
C.	G 7.	M 2.	T 4.
C 2.	H.	M 3.	V.
C 3.	H 2.	N.	V 2.
C 3 atlas.	H 3.	O.	Z.
C 4.	H 4.	O 2.	———
C 6.	H 5.	P, Vols. I, II.	75.
D.	H 6.	P, Vol. III.	

Other reports of the Survey are in the hands of the State Printer and will soon be published.

SINGLE SHEETS ANTHRACITE REGION.

In order to make the results of the survey in this region immediately available, 200 copies of each sheet (size 26×32 inches) will be sold singly as soon as printed. Remittances* for the same and communications respecting the Anthracite Survey should be addressed to

CHAS. A. ASHBURNER, *Geologist in Charge,*
907 Walnut street, Philadelphia.

General Map Anthracite Coal Fields, scale $\frac{1}{300000}$ths of nature (about $4\frac{3}{4}$ miles to one inch) showing the outlines of the coal basins and outlets to market; with list of working mines during 1882 and 1883 with their annual production,

Printed on light paper, ... Price $0 11
Printed on heavy paper, ... Price $0 12
Printed on light paper with counties colored, ... Price $0 13

Geological and Mine Sheets, scale 800 feet to 1 inch $\frac{1}{9600}$ths of nature, showing the geology, mine workings, and the shape of the floor of the coal beds by contour curve lines 50 feet vertically apart.

DELANO SHEET[1], Western Middle Field, in vicinity of Delano and East Mahanoy City, ... Price $0 22

SHENANDOAH SHEET[1], Western Middle Field, in vicinity of West Mahanoy City, Shenandoah, and Gilberton, Price $0 26

*The price assigned to each sheet includes one cent for postage. Where less than 10 sheets are ordered for one delivery, 5 cents must be remitted in addition to the price of the sheets, to pay for a paste-board tube and postage thereon.

GIRARDVILLE SHEET[1], Western Middle Field, in vicinity of Frackville and Girardville, ... Price $0 24

ASHLAND SHEET[1], Western Middle Field, in vicinity of Ashland, Locust Dale, Centralia, and Montana, ... Price $0 31

NANTICOKE SHEET[2], Northern Field, in vicinity of Nanticoke and Newport, ... Price $0 31

WARRIOR RUN SHEET[2], Northern Field, in vicinity of Warrior Run and Hanover; contains also skeleton map between Wilkes Barre and Shickshinny, (scale, 1 mile=1 inch,) . . . . . Price $0 26

PLYMOUTH SHEET[2], Northern Field, in vicinity of Plymouth, . Price $0 31

ASHLEY SHEET[2], Northern Field, in vicinity of Sugar Notch, Ashley, and South Wilkes Barre, ... Price $0 31

KINGSTON SHEET[2], Northern Field, in vicinity of Kingston and Plains, ... Price $0 36

WILKES BARRE SHEET[2], Northern Field, in vicinity of Wilkes Barre, ... Price $0 36

DRIFTON SHEET[3], Eastern Middle Field, in vicinity of Drifton, Jeddo, Ebervale, Stockton, &c., ... Price $

HAZLETON SHEET[3], Eastern Middle Field, in vicinity of Lattimer, Hollywood, Harleigh, Hazleton, Mt. Pleasant, &c., ... Price $

MAUCH CHUNK SHEET[4], Southern Field, in vicinity of Mauch Chunk and Nesquehoning. (See foot-note, page 4.)

LANSFORD SHEET[4], Southern Field, in vicinity of Lansford and Summit Hill. (See foot-note, page 4.)

TAMAQUA SHEET[4], Southern Field, in the vicinity of Coaldale and Tamaqua. (See foot-note, page 4.)

Topographical Sheets, scale 1600 feet to 1 inch $\frac{1}{19200}$ths of nature, showing surface topography in contour curve lines 10 feet vertically apart.

SHEET No. I, WESTERN MIDDLE FIELD[1] { in vicinity of Delano and Mahanoy City, ... Price $0 11

SHEET No. II, WESTERN MIDDLE FIELD[1] { in vicinity of Shenandoah, New Boston, Frackville, Girardville, &c., . Price $0 11

SHEET No. III, WESTERN MIDDLE FIELD[1] { in vicinity of Centralia, Ashland, Mt. Carmel, &c , ... Price $0 11

SHEET No. I, SOUTHERN FIELD[4], { in vicinity of Mauch Chunk, Lansford, Tamaqua, &c. (See foot-note, page 4.)

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1. Contained in Atlas W. M. A. F. Part I.
2. Contained in Atlas N. A. F. Part I.
3. Contained in Atlas E. M. A. F. Part I.
4. Contained in Atlas S. A. F. Part I.

Cross Section Sheets contain vertical cross sections, scale 400 feet to 1 inch, $\frac{1}{4800}$ths of nature; reference maps scale 1 mile to 1 inch, $\frac{1}{63360}$ths of nature; &c.

SHEET No. I, WESTERN MIDDLE FIELD[1]	4 sections through Myersville, Coplay, Morris, West Lehigh, Schuylkill, Glendon, Primrose, Hillside, Oak Hollow, Barry, Yatesville, Mahanoy City, Elmwood, Tunnel Ridge, and Middle Lehigh Collieries and East Mahanoy R. R. tunnel, ...	Price $0 09
SHEET No. II, WESTERN MIDDLE FIELD[1]	5 sections through Indian Ridge, Plank Ridge, Knickerbocker, Shenandoah City, Coal Run, St. Nicholas, Boston Run, Lehigh No. 3, Packer Nos. 2 and 4, William Penn, Bear Ridge Nos. 1 and 2, Stanton, Draper, Colorado, Lawrence, and Ellangowan collieries, ...	Price $0 09
SHEET No. III, WESTERN MIDDLE FIELD[1]	4 sections through Girard Mammoth, Cuyler, Hammond, Continental, North Ashland, Preston Nos. 1, 2, 3, and 4, Centralia, Hazle Dell, Bast, Tunnel, Big Run, Keystone, Potts and Franklin collieries, ...	Price $0 09
SHEET No. IV, WESTERN MIDDLE FIELD[1]	Sections through Mt. Carmel, Rough and Ready, Coal Ridge No. 3, Bellmore and Reno collieries; longitudinal section Mahanoy basin and geological map between Delano and Ashland, (scale 3200 feet=1 inch,)	Price $0 11
SHEET No. III, NORTHERN FIELD[2],	10 sections; through Boston, Plymouth Nos. 1, 2, and 4, Dodson, Gaylord, Avondale, Nottingham, Reynolds, Franklin, and Sugar Notch Nos. 9 and 10 collieries, .	Price $0 09
SHEET No. IV, NORTHERN FIELD[2],	10 sections; through Maltby, Enterprise, Forty Fort, Wyoming, "Harry E," Black Diamond, Mill Hollow, East Boston, Kingston, Henry, Burroughs, Prospect, and Midvale collieries, ...	Price $0 09
SHEET No. V, NORTHERN FIELD[2]	5 sections; through Pine Ridge, Mill Creek, Laurel Run, Conyngham, Baltimore, Diamond (No. 1,) Hollenback (No. 2,) Red Ash, Empire Nos. 3 and 4, and Stanton collieries, ...	Price $0 09

SHEET No. I, EASTERN MIDDLE FIELD[3],	5 general sections, scale 800 feet to 1 inch; through Highland, Eckley, Woodside, Stockton, Hollywood, Hazleton, Mt. Pleasant, &c., collieries, ... Price $
SHEET No. II, EASTERN MIDDLE-FIELD[3],	16 sections; through Highland, Woodside, Drifton, Eckley, Lattimer, Jeddo, Milnesville, Ebervale, Hollywood, Harleigh, &c., collieries, ... Price $
SHEET No, III, EASTERN MIDDLE FIELD[3],	9 sections; through Lumber Yard, Stockton, Diamond, Hazleton, Cranberry, Crystal Ridge, &c., collieries, ... Price $
SHEET Nos. I, II and III, SOUTHERN FIELD[4],	25 sections; through collieries L. C. and Nav. Co., between Mauch Chunk and Tamaqua, (See foot-note, page 4.)

Columnar Section Sheets contain sections showing thickness and character of coal measures, scale 40 feet to 1 inch, of coal beds scale 10 feet to 1 inch, &c., &c.

SHEET No. I, NORTHERN FIELD[2],	contains sections at Bennett, Pine Ridge, Enterprise, Henry, Wyoming, Oakwood, Prospect, Conyngham, Baltimore, Diamond, Hollenback, Laurel Run, Mineral Spring, and Red Ash collieries, ... Price $0 11
SHEET No. II, NORTHERN FIELD[2],	contains sections at Dorrance, Empire Nos. 2 and 4, Kidder, Stanton, South Wilkes Barre, Franklin, Sugar Notch, Ashley No. 6, Hillman Vein, &c., collieries . . Price $0 11
SHEET No. III, NORTHERN FIELD[2],	contains sections at Maltby, Forty Fort, Harry E, Black Diamond, East Boston, Kingston, Mill Hollow, Plymouth, Boston, &c., collieries, ... Price $0 11
SHEET No. IV, NORTHERN FIELD[2],	contains sections at Plymouth, Lance, Gaylord, Dodson, Wanamie, Alden, Avondale, Chauncey, Nottingham, Susquehanna Nos. 1 and 2, Hanover, Warrior Run, &c., collieries, ... Price $0 11
SHEETS Nos. I, II & III, SOUTHERN FIELD[4],	contains 79 sections at collieries L. C. and Nav. Co., between Mauch Chunk and Tamaqua, (See foot-note, page 4.)

Other Anthracite sheets are in the hands of the State Printer and will soon be printed.

The sale of the reports is conducted in accordance with the provisions of Section 10 of the Act of the 14th day of May, 1874, which directs that copies of the Reports, with all maps and supplements, shall be furnished *at cost of publication to all applicants for them.*

All the printed volumes and maps in stock have been transferred by the Board of Commissioners to the Department of Internal Affairs, where the sales thereof will hereafter be conducted.

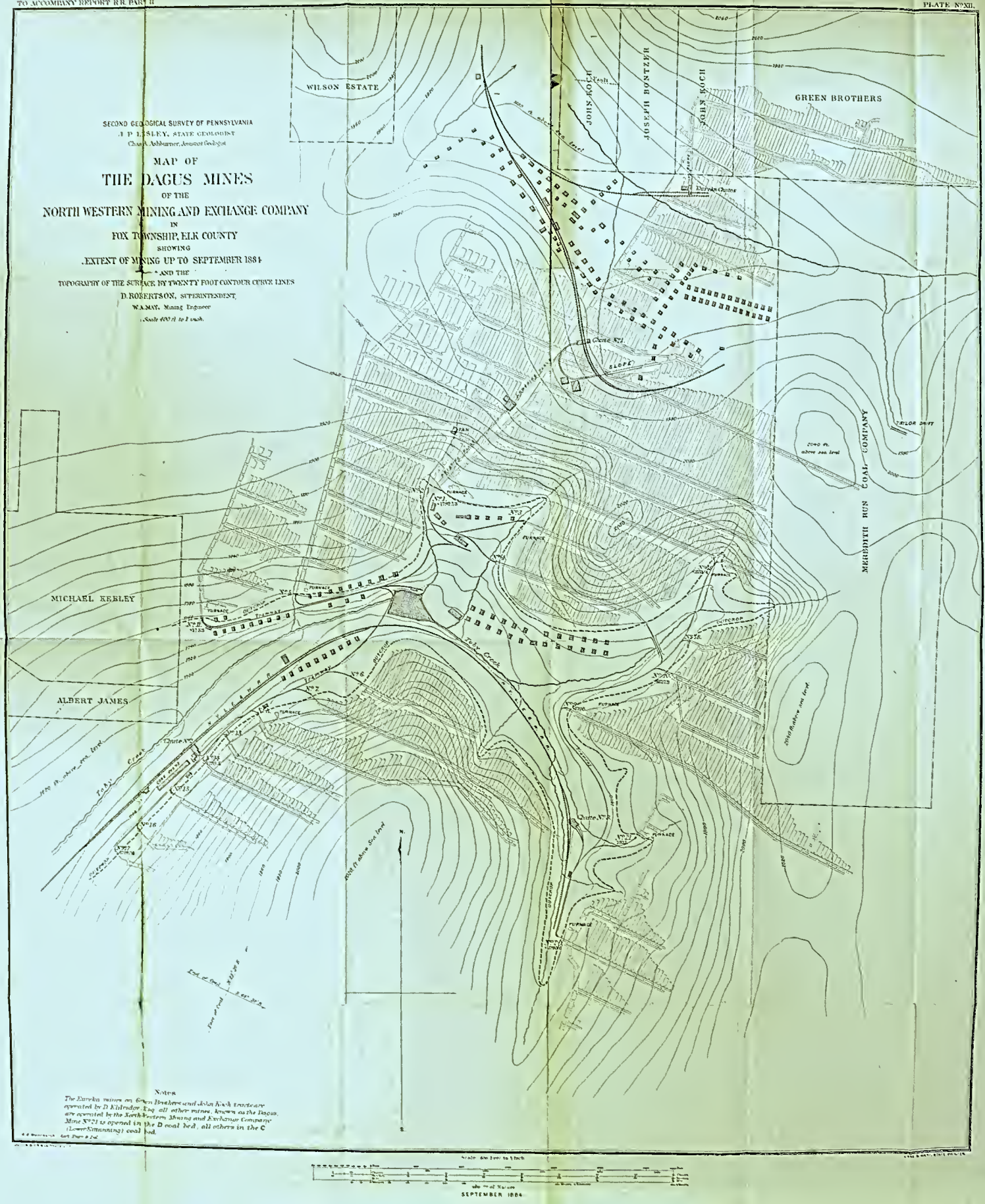
Communications relating to the work of the Survey should be addressed to J. P. Lesley, State Geologist, No. 1008 Clinton street, Philadelphia, and those intended for the Board of Commissioners to William A. Ingham, Secretary, No. 907 Walnut street, Philadelphia.

For instructions for purchase of single sheets of the Anthracite Survey, see page 9.

All letters and orders concerning the purchase of Reports and remittances for the same, should be addressed to

J. SIMPSON AFRICA,
Secretary of Internal Affairs
Harrisburg, Pa.

March 1, 1885.


SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA
J. P. LESLEY, STATE GEOLOGIST
Chas. A. Ashburner, Assistant Geologist
MAP OF
THE DAGUS MINES
OF THE
NORTH WESTERN MINING AND EXCHANGE COMPANY
IN
FOX TOWNSHIP, ELK COUNTY
SHOWING
EXTENT OF MINING UP TO SEPTEMBER 1884
AND THE
TOPOGRAPHY OF THE SURFACE BY TWENTY FOOT CONTOUR CURVE LINES
D. ROBERTSON, SUPERINTENDENT,
W. A. MAY, Mining Engineer
Scale 400 ft to 1 inch.
WILSON ESTATE
JOHN KOCH
JOSEPH BONTZER
JOHN KOCH
GREEN BROTHERS
MICHAEL KEBLEY
ALBERT JAMES
MEREDITH RUN COAL COMPANY
Tuby Creek
Eureka Chutes
Chute No. 1
Chute No. 2
Chute No. 3
SLOPE
FAN
FURNACE
OUTCROP
TAYLOR DRIFT
2040 ft. above sea level
2000 ft. above sea level
Notes
The Eureka mines on Green Brothers and John Koch tracts are operated by D. Kildredge, Esq. all other mines, known as the Dagus, are operated by the North Western Mining and Exchange Company. Mine No. 21 is opened in the D coal bed, all others in the C (Lower Sittanning) coal bed.
Scale 400 feet to 1 inch
SEPTEMBER 1884